JPRS-UCC-84-003

4 May 1984

USSR Report

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS-UCC-84-003

4 May 1984

USSR REPORT

Cybernetics, Computers and Automation Technology

Contents

[III - USSR - 21C S&T]

(BLANK)

GENERAL

EVOLUTION OF INFORMATION SCIENCE DISCUSSED

Moscow PRAVDA in Russian 12 Nov 83 p 3

[Interview with Academician V. S. Mikhalevich, director of the Ukrainian SSR Academy of Sciences Institute of Cybernetics imeni V. M. Glushkov, by PRAVDA correspondent O. Gusev in Kiev: "Informatics Changes Features: Science Extends Horizons"]

[Text] As reported earlier, the USSR Academy of Sciences general meeting decided to organize the Department of Computer Engineering, Information Science and Automation. Formation of it has begun. PRAVDA correspondent O. Gusev asked Academician V. S. Mikhalevich, director of the Ukrainian SSR Academy of Sciences Institute of Cybernetics imeni V. M. Glushkov, about the prospects for this field.

[Question] To start, could you explain the concept of informatics?

[Answer] This term per se is a firm entry in dictionaries and encyclopedias. But until recently, it traditionally meant the technology of scientific research, exchange of scientific and technical information, document recording, and library affairs. But the development of electronic computers forced a new way of looking at the use of information essentially in all major areas of society--in planning and management, education, medicine, services, environmental protection, and of course, in industry. We mean its qualitative restructuring on a base of manipulators and programmable robots, and automated systems for design and control. Therefore, in the next editions of the dictionaries, the concept of informatics, obviously, must be entered in its broader sense.

[Question] It seems informatics is more and more closely related to computer systems for information acquisition, transmission and processing?

[Answer] Yes, this complex scientific and technological discipline studies first of all the major aspects of development, design, creation, and "incorporation" of machine systems for data processing, and their effect on the life of society. The main focus here is on the need for technological restructuring of management based on modern computers. Therefore, informatics is very quickly entering into life especially now when, as comrade Yu. V. Andropov

noted in the June (1983) Plenum of the CPSU Central Committee, "We are faced with the huge effort of developing the machines, mechanisms and technologies of both today and tomorrow. We have to automate industry and ensure the most extensive use of computers and robots and introduction of flexible technology which allows rapid and efficient reconfiguration of industry to manufacture a new product."

To move forward confidently in this great cause, a "pilot" is also necessary. You see, it is important to accurately define the path of interaction between people and computers. Before this was not always done and that is why there often were cases when first computers were installed and then the personnel were selected for them, the software was written, the jobs were sought, etc. Hence the low yield from the pool of computers in a number of enterprises, sectors and regions.

Those and a number of similar shortcomings in forming social demand for computer systems, disparity in engineering policy--sometimes merely machines, and not computer complexes and automated systems, were delivered --as well as the lag in software development, the creation of data banks without it being fully clear who needed them in first place, retarded, and even now often still hold back increasing the yield of even the most modern electronic computers.

[Question] And informatics as a field of knowledge evidently can become just the "tool" for improving data processing?

[Answer] Not only can become, but is becoming. The most progressive use of computers, when the basic streams of information "flow" inside machines or between them, while man receives only the minimal information, but ready for further use and decision making, is afforded not only by a high level of computers and training of personnel for them, but also by appropriate modeling complexes, organizational structures, staffs and forms of user documents.

Only interaction "on equal grounds" between the computer and its "master" can fully uncover the large reserves in machine technology of data processing. The comprehensive scientific discipline in question helps to achieve mutual understanding between the engineer and the machine. How to more quickly master the principles of informatics is another matter.

[Question] That is, specialists in this field are called upon to propose optimal alternatives for "adapting" machine systems and their software to managerial structures and "people" on the one hand, and on the other, for adapting structures and employees to machine systems and software?

[Answer] That's right. Information processing technology, powerful already since it emerged, in this case alone will reveal in full measure its social utility and will become an organic element of everyday practice.

The organizational-economic and social aspects of optimal use of computers and their networks, as is known, received much attention from the founder of our institute, Academician V. M. Glushkov. He persistently fought against sheer

technicism in the evolution of computer systems. And he too in his time proposed stepping up research in informatics even more extensively in addition to advocating cybernetics research.

Active restructuring of the technology of management and other information-communicative processes and putting them on an industrial basis must proceed not empirically, not by trial and error, but first of all by actively generalizing the experience already accumulated in computers, cybernetics, modeling, programming, theory of information and decision making, economic science and office automation.

[Question] Thus, one can say that informatics helps not only place the burden of routine processes for information processing on machines, but also support the most complex processes of preparing and making optimal decisions?

[Answer] Of course. The "information explosion" requires creating and using systems capable of promoting intensive growth in the scientific and economic potential of the country by using computers. Progress in the field of cognition, ordering, and optimization of various national economic processes is a critical area of application of this branch of knowledge and new information technology which are called upon to promote scientific and technical progress.

It is remarkable that the effectiveness of informatics is steadily growing. Thus, new capabilities in management were opened by the transition to third-generation computers and two-way channels for data communication combined with so-called intelligent terminals. Now, various kinds of "computer" conferences have been held, alarm control systems are operating, and design and output of archival information, etc. are being automated.

With the emergence of microcomputers and built-in control systems, it is as if computers have received a second wind. All of these things are rungs on the ladder to the cardinal transformation of industry on the base of manipulators and programmable robots which we have now mastered, the rungs leading to the development of flexible automated industries, and shops and plants "without people." All this is the desirable and necessary "invasion" of computers into the most varied areas, from art to everyday life.

Especially broad prospects for informatics are being developed in connection with rapid progress in microprocessor technology. You see, hundreds of thousands of active elements now, and millions in the near future, can be placed on one chip. Such "dwarfs," comparable in power to medium-sized computers, can be built into the most varied machines and units.

8545
CSO: 1863/82

YES-1033 COMPUTER USED FOR OBJECTIVE SOCIALIST COMPETITION RESULTS

Moscow STROITEL'NAYA GAZETA in Russian 7 Oct 83 p 2

[Article by V. Semenov, candidate of economic sciences, Tallinn: "How the Computer Will Help"]

[Text] A task in a decree recently adopted by the CPSU Central Committee concerning socialist competition reads: "Raise exactingness in determining competition winners. Ensure the really best collectives and employees are encouraged...."

The Center for Administration of Construction and Complete Outfitting, Estonian SSR Ministry of Construction, initiated a new method of summing up socialist competition results by using the YeS-1033 computer. Using the computer helps to more accurately carry on competition by indicators for real output individually for plasterers, painters, and installers--by seven occupations in all.

Competition and the computer. By what objective need was so close a combination of these two concepts predetermined? Was it dictated by time, which has imposed on all of us the fetish of mandatory machine printouts? Of course not. Using a computer in the practice of competition helps ensure not only timeliness in the calculations, but also objectivity and effectiveness, which is the main thing.

The ministry tried to set up competition between brigades on real output indicators for many years. But progress was only so-so. The process of organizing competition had been divided into many small phases. Some gathered the source data, others processed it, and yet others summed up the results. Well it also happened, and happens up to the present time, that yet certain others have the final say-so on who gets a prize. The smack of subjectivism substantially reduced the emotional tone in the working collective.

Center specialists, Vladimir Vayngort, Merike Valdlo, Natal'ya Rechkina, Lev Gilin and Gennadiy Kuripchenko, decided to organize summing up results so that the subjective aspect is completely eliminated--a major condition for organizing competition as a whole. They compiled new computer programs so that

accounting printouts can be used for efficient summing up of results in construction trusts and administrations. Center specialists also worked soundly on the form for notifying work brigades of results.

The possibility of drafting a reliable "Regulation on Brigade Competition by Real Output" emerged for the first time. The regulation was actually written and introduced.

But what does the concluding phase of competition, the summing up of results, look like now?

On those days when the time comes to perform the mass result calculations, Natal'ya Rechkina and Lev Gilin literally do now leave the computer. They know nobody wants a late result. Let time slip by and the results will be summed up in a construction organization by its customary criteria.

The computer outputs printouts. They contain information on the work of brigades by specialties. Shown for each brigade is the volume and list of work completed and the time spent on it. Shown are the listed brigade strength and the accounting, which can be established from actual time spent on work completed. In a word, the printouts contain all the components for objective comparisons and conclusions. After receiving such a printout, an employee in a trust OTiZ [department of labor and wages] will, perhaps, have to attend to just one thing: Get an artist to better draw the graphics related to publicizing the competition.

In the concluding stage, the computer prints information on the distribution of brigades throughout the ministry as a whole, based again on real indicators of output per shift and normalized brigade-wide output.

Let us now return to the primary question of whether using a computer supports some creative aspect or only simplifies accompanying operations: printouts are read, a poster is drawn up and indicators are posted on a board. There is a creative aspect. In the course of mutually exacting discussions on competition results in the brigades, new proposals for improving competition organization are always made. The employees are very interested in who came out ahead and why, pay attention to difficulties not taken into consideration in the work of neighbors who did not win a prize, point to shortcomings in technical documentation.... Specialists in the ministerial center for administration of construction and complete outfitting must be aware of all these judgments.

Rating criteria stored in the computer is not fixed. The computer, of course, only analyzes and counts. But the skilled and experienced specialist in organization as before takes part in managing competition.

Using a computer highlights the shortcomings of the prior system for summing up results, often based on emotional or business-condition arguments. Everyone knows the tradition of ratings is very strong in the current generally accepted technique for summing up competition results. When some foreman has

moved up into the "ring" of leaders, and when some interesting undertakings on labor organization are linked to his name as well, then no hand is raised to one day exclude him from this ring. He, the traditional outstanding worker, is willingly charged with speaking at meetings; he knows the subject well and speaks well; he is regularly sent first to the republic meeting, then to the all-union. He is a leader.

But meanwhile in the work collective, the leader is now mentioned with a tinge of criticism: both the output is not among the best, and injuries have increased....

The computer is free of the aspects of business conditions, and the participation of a social organization like the group of center specialists in summing up the results raises work prestige and the significance of the final rating in competition results in the eyes of a worker.

The practice of calculating output and determining general results on a computer was approved by the republic trade union committee presidium. Competition among our composite brigades has been a bit more lively and interesting. The individual collectives are now unable to make the ranks of the leaders so often: once or twice a year according to quarterly results. And even this pertains only to the best. The leader who had once shown some economic initiative loses neither priority nor honor. As for the prizes and ovations for the best results, let the strongest actually receive them.

This new method was used for the first time in the Estonian Ministry of Construction in the first quarter of last year. And since then the trusts have regularly contracted with the center for administration of construction and complete outfitting for design and preparation of computer programs for determining socialist competition results in the concluding phase.

8545
CSO: 1863/82

SERVICE, STANDARDIZATION, TRAINING EXCORIATED

Moscow LITERATURNAYA GAZETA in Russian No 48, 30 Nov 83 p 12

[Article by V. Vinokurov, doctor of physical-mathematical sciences, chief of the Higher Mathematics Faculty of the Moscow Technical Aviation Institute imeni K. E. Tsiolkovskiy and K. Zuyev, candidate of philosophical sciences, docent: "Electronic Moonlighters: Is It Possible To Tolerate Such Service?"]

[Text] Today a computer does not surprise you. It is more the case that you would be surprised if your organization, pretending to be solid, still does not have a computer. Every self-respecting firm strives to get oneself a computer.

Let's say that you have become an owner of an YeS-1033 computer (the series acknowledged as basic by the countries of socialist friendship), and that it has started to produce long-awaited results. But, like everything in this world, your computer is not insured against breakdowns. Who will fix it?

If you have an agreement with "SoyuzEVMkompleks [Union Computer Complex] then a specialist will arrive shortly. This organization, however, as a prerequisite for signing the agreement, demands that your equipment has functioned faultlessly and that you were fully manned with specialists. You will hardly every meet such an ideal situation in a newly created computer center, but this is precisely what is needed for service. The fastidious "SoyuzEVMkompleks wants nothing to do with inconvenient clients unless it delivers equipment which is in short supply. And it comes out this way: the owner repairs it himself, although the mythical "completion of all work" covered by the agreement is written down on paper.

We might add that not everybody has an agreement with SoyuzEVMkompleks and in accordance with the instructions on the repair claim, they turn to the regional branches of this association. And here they accept the claim and promise satisfaction in about two months. You are done for: 16 personnel with an average salary of 140 rubles. What will they be doing for two months? And machine time (at 90 rubles per hour) for two-shift work? In round figures your loss will amount to about 80,000 rubles. How can this be?

In such a situation we will hardly find a manager who will agree to follow the course of action prescribed by the instructions--to complacently await the work of the electronic service. A way out of this predicament is not, after all, so complicated: those same specialists from SoyuzEVMkompleks or competent people from other organizations will fix the breakdown in two or three days for 200-300 rubles (in cash, of course). Compare: 200-300 rubles or 80,000 rubles! It is clear that the managers prefers the electronic moonlighters; what remains is to find the means to do it.

Unfortunately methods of work have been introduced into electronic service that are characteristic of the already fairly well worn out world of sanitary technology or the well studied sphere of self-service. The difference is that a breakdown in a toilet or a carburator may, although it is stretching the point, be considered a personal problem of a specific citizen, but electronic service without stretching the point at all is an affair of state importance.

In actuality many problems arise even before a breakdown. Even before the moment when you buy the computer. A large computing machine requires preparation of the space: anti-static floors, stable current, air conditioning, etc.

The owner is occupied with all this work, as well as transportation, installation, adjustment of the purchased computer by non-professional or semi-professional means.

Let's ask this: why do some organizations want to obtain imported technology? In and of themselves our computers do not lag the world level on a number of basic parameters. But the purchase of a foreign computer automatically ensures the owner of its installation, service and repair. Defects are removed in the course of several days, not months. It is not necessary to coax them. An integrated approach is necessary for electronic service in a large degree, more so than in the service of other types of complex contemporary technology. It is necessary to combine in one organization the carrying out of all types of work which precedes the introduction of the computer into "working life." The complexity and rapidity of service of electronic computing machines must not be lower than the level guaranteed by foreign firms.

Up to now we have been discussing the service of a Unified Series computers. And how is it with other computers? Here one problem still awaits us: the absence of standardization of software and equipment. It is not at all common that having purchased a computer of one brand, you may use the equipment of other brands. The systems of the Elektronika type cannot be connected with the SM systems although according to their parameters they are practically identical. One even comes up against such cases when the machines and equipment of one series (for example the YeS-1033 and YeS-7168 display of the Videoton firm) do not interconnect, which contradicts the very principle of adherence to one series.

This situation may be compared, if you will, with the fact that having bought a child's erector set, you unexpectedly discovered that the

connecting screws were thicker than the holes into which they must be placed in order for the set to be transformed into another structure. The necessity is long overdue for the development and approval of standards which all newly created electronic computing equipment must meet independent of departmental subordination of enterprises.

The standardization of software (algorithmic languages and programs) for computers is needed. Its cost is constantly growing. It is apparent that a great many people, not connected with computing technology, will be surprised to find out that the cost of programs already developed is in the billions of rubles. Collectives of qualified specialists work months and even years on other programs (such as, for example, for processing information from satellites). Annually in the USA, sales of sets of programs which are designated for the solution of a specific type of problem, come to approximately three billion dollars (these are the so-called packages of applied programs).

The presence of a large number of programs in different algorithmic languages seriously complicates the training of cadres. The translation of programs that one already has into a new language only because the computer does "not understand"--is an expensive and not always rational undertaking. Translations lower the labor productivity of programmers. Interest for this profession falls. This is a dangerous tendency, in as much as a deficit of specialists is already becoming evident and may grow in the coming years. Then we will confront the fact that we will not be able to fully and effectively load the entire stock of computers.

An increase in only the quantity of programmers will not solve the problem. According to estimates of foreign specialists, with current labor productivity of programmers, the demand for them by 1990 will be tens of millions of people, which is many more than are now required. It is clear, of course, that even a smaller number is unrealistic. The realistic way is to raise the output of this category of specialists, actually changing the conditions of their work.

The question about preparing cadres in systems programming and computer electronics is extraordinarily acute. Although there are faculties of applied mathematics in several technical institutions of higher learning which are supposed to prepare them, nevertheless they are producing traditional specialists under a new mask. The Ministry of Higher Education clearly must more attentively monitor the preparation of students in severely deficient specialties.

It is known that authors of inventions and rationalization proposals are supported by corresponding laws in jurisprudence. Such legal norms must guarantee authorship for complex programs. Their absence makes the use and exchange of programs difficult. It often happens that they reinvent the wheel or acquire needed programs by doubtful legal means.

Here's the bottom line. In order for the computer to work with full efficiency, it is necessary to operationally solve a whole complex of

questions: organizational, material-financial, technical, legal. Without the active participation of the appropriate ministeries and departments, affairs in this area will not be corrected, but rather, will become more complicated.

12596
CSO: 1863/90

PROBLEMS WITH COMPUTER LOAD AND DATA PREPARATION

Moscow EKONOMICHESKAYA GAZETA in Russian No 48, Nov 83 p 7

[Article by A. Golubets, chief of the Bureau of Computing Centers of the Oblast Statistical Administration in Donetsk: "What Makes Work Complicated"]

[Text] On the whole the plan for loading computers at enterprises and organizations throughout the Donetsk Oblast is being fulfilled. At the same time in a number of computing centers the machines are not always used effectively. To a large degree, a subjective factor is at work here: certain managers of organizations do not consider fulfillment of the plan for loading computers a matter of the highest priority.

There are other reasons. For example, at the present time the prevalence of insufficiently effective equipment for preparing information on punched cards and punched tape complicates work with computers. And this is not economical: Tens of millions of punched cards are expended for one-time use. It seems to me that there is an urgent need to increase the production of the most advanced equipment for the preparation, input and output of information for computers on magnetic tape and disks.

12596
CSO: 1863/90

LACK OF INCENTIVES, OTHER PROBLEMS IN USE OF CAD

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 24 Dec 83 p 2

[Article by V. Shkabatur, chief of the Automation of engineering-technical calculations section "Ukrgipromeza" and L. Lyakhovetskiy, chief specialist of the pipe rolling section, candidate of technological sciences: "The Electronic Partner of the Engineer"]

[Text] The authors of the article "What's a Computer to a Designer?" have pointed out the important and serious problems of the mass application of electronic computing technology in the development of designs of future enterprises. But, it seems, they have payed insufficient attention to problems connected with the creation of automatic design systems. And this is the most effective way of applying complex and expensive apparatus in our work.

Designers began to use computing technology almost from the very moment when its potential was actively revealed. Until recently, however, we have basically placed the most time-consuming, routine calculations on the shoulders of our electronic helper. This has made life easier, but has not changed in principle the approach to the process of developing a design.

And here's how it happend once... A continuous production line of pipe sections was being designed. Everyone knew in general terms how it must be. But doubt arose as to how many pieces of equipment should be used. According to preliminary calculations, the specialists of the manufacturer's factory suggested putting 93 technological units in the continuous line. Although everyone understood that the amount of equipment was padded, no one ventured to reduce it.

Then the workers of the pipe rolling section of the Ukrainian State Institute of Metallurgical Factory Design formulated the problem and submitted it to the computer. The machine thought it over for a while and then gave an unexpected answer: 93 technological units were not needed, but only 23. Think of it, four times fewer!

The computer's answer was so well argued that, in spite of the initial shock, this solution convinced all interested parties. The continuous line was adopted in precisely that configuration. Getting ahead of ourselves, we

will say that the actual economic effect of this optimal variant for the year was more than a half million rubles.

Having verified the potential of computing technology in the solution of local design problems and believing in this potential, specialists of our institute, together with scientists of the Cybernetics Institute of the Ukrainian SSR Academy of Sciences, the All-Union Scientific Research Pipe Institute and colleagues from related design enterprises undertook the creation of a system for the automatic design of pipe shops.

But here it became necessary to confront a series of serious problems, the solution for which designers themselves do not have the power.

In particular, the problem of the so-called data bank was acute for us. That is, the creation, in machine-readable form, of an information bank of normative and averaged statistical indicators of the specific expenditure of materials and energy. As long as there isn't one, it is extremely difficult to supply an operational estimate, say, for the shop being designed. Here, in our opinion, the scientific research institutes of the field and the scientific subsections of Gosstroi SSSR [State Committee on Construction] must speak out.

In a general system of automated design graphics devices are included. Using them the computer can outline different variants of the plan for the playout of the apparatus and thus as it were complete the technological direction of the design.

Finally, the problem of the support of computer centers of design institutes with peripheral equipment, especially with display devices which aid the direct dialogue of man with machine, has long awaited a solution. We talk a lot about this, but the situation stays the same. From the point of view of the national economy, such works usually produce a great effect. However, both designers and those who use automated design systems confront serious difficulties.

In general, as the authors of the article "What's a Computer to a Designer?" have correctly noted, design organizations should centrally received standardized software and hardware, and not act independently.

The list of disorders is not exhausted by this. How much, for example, does the absence of any economic status for automated design systems cost? Strange as it may seem, the most rational application of computing technology in design is not encouraged at all. It's even the opposite, in as much as the cost of the design directly depends on the volume of building-assembly work. Using optimal solutions, which reduces this volume, is turned into a reduction of the rewards for design instead of producing encouragement.

Today even skeptics understand that the computer is homage to a fad, but a necessary element in the technological process of design. It transforms design from an art, the level of development of which depends on the

experience and knowledge of the designer, into an orderly science, which accumulates the collective knowledge of the best design specialists and which allows the preparation of the optimal design in the shortest time.

12596
CSO: 1863/90

UDC 681.3:681.7.014.3

AUTOMATED IMAGE PROCESSING (PART 1, SPECIALIZED IMAGE PROCESSING SYSTEMS)

Vilnius TRUDY AKADEMII NAUK LITOVSKOY SSR, SERIYA B: KHIMIYA, TEKHNIKA, FIZICHESKAYA GEOGRAFIYA in Russian No 3(136), 1983
(manuscript received 12 Mar 82) pp 97-103

[Article by S. E. Val'teris, S. L. Gorelik, I. A. Ovseyevich, I. K. Punis and L. P. Yaroslavskiy, Institute of Engineering Physics Problems of Power Engineering, Lithuanian SSR Academy of Sciences; USSR Academy of Sciences Institute of Information Transmission Problems]

[Text] 1. Introduction. Prominent among problems in automating information processing in various fields of science and technology is processing optical images of objects, media and fields in a broad spectrum, from the ultrasonic and infrared to the ultraviolet and X-ray, in which informative features and information characteristics consisting in images have to be detected and determined.

In recent years, image processing has become a scientific field of its own aimed at solving an extensive number of applied problems facing other fields of science, industry, agriculture, medicine, cosmonautics, etc. The importance of this new field to the national economy has been stressed time and again in a number of party and government directives. In particular, in a number of major scientific research projects underway in the country and included in special-purpose comprehensive programs, we find problems of developing new and improving existing automated image processing systems to increase effectiveness of scientific research and improve technical and economic indicators for objects of new technology in scientific organizations of the USSR Academy of Sciences and sectors of the national economy.

A promising direction in automated image processing is the development of specialized software and hardware meeting the requirements of image processing. These issues, in particular, were dealt with at an out-of-town session of the permanent seminar on "Automated Image Processing Systems," Commission on Automated Image Processing Systems (ASOIz), Council

on Scientific Research Automation under the USSR Academy of Sciences Presidium. It was held on 29-30 October 1981 at the USSR Academy of Sciences Institute of Engineering Physics Problems of Power Engineering.

Considering the relevance of automated image processing to specialists on scientific research automation in USSR Academy of Sciences institutes and in other organizations, we are publishing a series of articles analyzing achievements in developing specialized systems, methodological issues and results of efforts on automation of image processing underway in the USSR Academy of Sciences Institute of Engineering Physics Problems of Power Engineering.

This article is a brief review and analysis of existing specialized image processing systems and trends in their evolution.

2. Current Status of Efforts in Automated Image Processing Systems

Well-known progress has been made in the USSR in developing methods and hardware for automated image processing. Thus, for example, the AL'FA digital SOIz [image processing system] was developed at the USSR Academy of Sciences Institute of Information Transmission Problems [1]. It was used to successfully process photographs of the surface of Mars and Venus which were taken from automatic interplanetary stations. This system is now used in efforts on geologic interpretation of aerial photography and medical diagnostics of X-rays. Automated image processing systems for processing aerial photographs were developed at the USSR Academy of Sciences Institute of Space Exploration, the USSR Academy of Sciences Siberian Department Computer Center and Institute of Automation and Electrometry, and others [2-4].

High-throughput precision systems for mass processing of film information from tracking cameras based on "flying spot" scanners with transmitting cathode ray tubes [CRTs] were developed to automate experiments in nuclear physics. The best known systems are the ELAS-MEZON, MELAS [5], AELT-1 and AELT-2 [6] which, as experience has shown, can be successfully used to process images in medicine, biology, geodesy and cartography.

Considerable progress has been made in efforts to automate microscopic research. Over the last 10-15 years, thanks to cooperation between Academy of Sciences institutes, industrial enterprises and sector institutes, development and industrial production was organized for the PROTVA, RASTR, MORFOKVANT and other automated scanners and systems to analyze micro-objects [7].

Much attention has been paid to image processing in foreign countries as well. Evidence of this in particular is the large number of publications and symposiums and the emergence of special periodic publications and monographs dealing with image processing problems [8-10]. Major image processing centers have been established in a number of the developed capitalist countries.

Image processing, which emerged first as a collection of methods and engineering principles for solving particular problems, is acquiring its own theoretical and methodological base which is based on achievements in the classical sciences: information theory, signal theory and the theory of statistical solutions [11-14]. The same trends have shown up in the evolution of image processing hardware which at first was adopted from general-purpose hardware (television, computers, phototelegraphy and optics) designed for solving problems differing substantially from those in image processing (image generation and transmission, numeric computations, etc.). But now, features of specialization in both hardware and software are emerging.

3. Problems and Trends in Evolution of Image Processing Systems

Up to now, mainly general-purpose hardware in which mostly serial operations are performed on the signal has been used for solving image processing problems. The functional structure of these processing systems includes image input scanners based on television, phototelegraphic or optomechanical sensors, computer interfaces, image displays and output devices. Image processing is also divided into a number of sequential stages. The most common are:
1) image input which includes scanning an image field (object of observation), photoelectric conversion (or conversion of some other physical quantity into an electric signal), analog-to-digital signal conversion, transmission of digital samplings through a channel for computer communication and loading of computer information storage devices;
2) digital signal conversion: operations for spatial filtration, geometric transformations, measuring of various quantities in images and coding;
3) making decisions (in automatic processing systems) from measurement data;
4) reproduction of images (output) which includes polling the storage unit in which the digital signal is stored, digital-to-analog conversion and conversion of an electrical into a light signal.

The most time, as a rule, is spent on the second processing stage due to mismatches between the structure of operating devices and computer information storage devices and that of an image and the algorithms for converting it.

Thus, for example, in image processing, a typical operation is analyzing the neighborhood of each point in the image field. In doing so, fetches from computer memory and arithmetic operations for the neighborhood require a large number of serial elementary computing operations. To reduce computation volume, various types of algorithms are used to speed up conversions [1, 14, 15]. Actually, these algorithms are attempts to increase image processing system throughput without changing hardware structure.

Let us note that these algorithms are suited only to a limited class of problems. For example, the algorithms for a fast Fourier transform [FFT] are ill suited to designing spatial nonuniform filters. Even less suited are the storage devices in digital systems for effecting geometric transforms. In such transforms, as a rule, repeated access to external storage, interpolation of samplings and a number of other operations are needed. As a result, geometric transforms in digital form require large amounts of time and storage. Since

general-purpose hardware is inadequate for image processing, specialized hardware must be created and developed. Such hardware must have a structure which supports parallel organization of algorithms for spatial filtration or geometric transforms and overlapping of various processing stages (for example, input and spatial filtration) when possible.

Very promising for development of image processing systems are optical methods which enable high throughput in performing spatial filtration operations [16-19]. But optical methods face a number of difficulties due to poor compatibility of optical processors and storage devices with electronic hardware which has great flexibility in managing and converting information into various forms of representation. This is needed, for example, in decision making or in measurements on images.

One system [18] has a software-controllable stack of spatial-frequency and holographic filters interfaced to a dynamic filter registration unit, a computer with a control console used to control the stack and dynamic registration unit, and a television reader interfaced to a display. This system is used to produce specific objects and improve analyzed image quality.

The hybrid optical-digital system discussed in [16] has a tri-lens coherent optical processor controlled by a digital processor. Used for control are input and filter plane scanners based, for example, on light-valve CRTs [1°]. There are a number of other examples for implementing hybrid optical-electronic image processing systems with a similar configuration [16, 17, 19].

Analysis of these systems shows their shortcomings can be traced to complexity in developing a controllable electronic beam for a transparency and to the long time for scanning filter and image planes. Also difficult is implementing adaptive processing algorithms (although there are engineering solutions of interest [15]), spatial-nonuniform conversions and some other operations. Therefore, the main efforts in developing optical-electronic hybrid processing systems have been focused on developing more flexible devices for controlling conversion parameters. Efforts [20, 21] deal with a promising result obtained in this direction and incorporated in developing a new class of systems: optical-electronic scanning systems with electronic-optical control.

A feature of the scanning electronic-optical processor is overlap of a serial operation, scanning of an image with serial-parallel operation, by integration with any weight from the neighborhood. This combination allows saving much time and hardware for brightness and geometric conversions in the spatial frequency spectrum. A given characteristic of a spatial filter is generated by electron beam conversions with subsequent excitement by this beam of a luminescent screen on a tube. This is how the scanning light aperture is formed. This aperture undergoes several serial discrete conversions at each point on the image being scanned. The signals obtained in the corresponding discrete moments of time are then combined with weights or undergo some other computing procedures.

Aperture dimensions, form and orientation are controlled in the conversions. Thus, in this system, the integral operation of convolution of the distribution of photo medium transparency with the distribution of energy in the light aperture becomes an elementary operation. Geometric transforms are also made in parallel with scanning. The flexibility of the system and possibility of implementing it with existing hardware enabled its extensive functional capabilities and the possibility of its current extensive use [22-24].

Scanning optical-electronic computer systems for image processing with system concepts similar to that discussed can also be implemented with other physical effects. In particular, scanning light aperture parameters can be controlled by using optical lenses controllable on the basis of nonlinear electro-optical effects. The concept of processing in image scanning can also be implemented on the basis of array photoelectrical converters, in particular with sensors using photodiode arrays [25]. In such transducers, which are one or more large-scale integrated circuits, complex and at the same time flexibly reconfigurable apertures can be synthesized which can also be used in synthesis of spatial filters. Attention should also be called to the effort on developing an optical-electronic device for parallel-serial functional scanning of an image [26], the idea of which consists in generating an image of an extended light source on the transparency being scanned, multiplying the modulated light flux and placing photo masks with specified analysis contours in the output plane of the array multiplier. With movement/shift of the spatially spread light source relative to the transparency, simultaneously generated in electrical circuits for the array of photoelectronic multipliers (FEU) positioned behind the masks is a series of signals which determine the results of reading according to selected directions for analysis. Another type of optical-electronic processing is discussed in [27].

In addition to parallel and parallel-serial image processing systems, R&D based on optical-electronic methods is underway to develop parallel digital structures for performing computing operations and storing an image [28, 29].

A promising direction in developing digital image processing hardware involves taking into account the specific structure of the image signal which allows representation as a set of "bit cuts" in contrast to traditional methods based on representing an image as a set of samples [30].

The new approach in image representation is also producing new architecture for a digital computer system; comparing the prospects of this with alternative architectures based, for example, on pipeline processing or traditional modern computer architecture shows the advantages of the "bit cut" method in which image processing is built on the principle of simultaneous operations for all cuts of an image being converted and parallel processing of computations for each operation.

The trend to specialize is also showing up in development of image processing system software. A number of efforts [5, 6] have appeared in which problem-oriented language facilities and systems software are being developed in addition to program modules designed to effect specific conversions. The

structure of problem-oriented facilities substantially depends both on tactics of using appropriate automated image processing systems and on the hardware structure used. Considerably different, for example, are the approaches to developing software in solving problems of mass processing of images by using specialized hardware [31] and in modeling image conversion processes in television systems on general-purpose Unified System computers [32].

One of the most typical problems in image processing is measuring various values on images [15, 33, 34]. Solving this problem requires essentially all types of image conversions: geometric, brightness, linear spatial filtration, analog-to-digital conversion of the signal and, finally, generating estimates of values being measured. In doing so, a specific requirement is high precision of conversions combined with high rate of measurements; therefore, especially relevant in measurements is the problem of optimal interaction of various pieces of hardware: optical and electronic, analog and digital.

An example of a specific applied problem in image processing is developing a complex of hardware and software for photogrammetrical estimation of surface relief from aerial photo images. The optimal strategy in solving this problem includes geometric transforms of local sections of the image field, linear conversions (calculation of cross correlation function for fragments, identification of contours, etc.), search for extremal values of two-dimensional functions and some other operations; sophisticated hardware and software is required to implement them. The effectiveness of using hybrid electronic-optical system for image processing in performing geometric transforms, identifying and measuring parameters of reference crosses, and in identifying contours by anisotropy should be noted.

4. Conclusions

1. Based on an analysis of status and trends in development of specialized image processing systems, it was found that the emergence of its own theoretical and methodological principles and expansion of the range of problems being solved for science and industry have facilitated the formation of image processing as a direction in science and technology of its own.

2. The following basic problems facing this direction have been identified:
I. Development of principles of mathematical modeling of images, as signals, with regard to specifics of image processing problems.
II. Research of the role and interrelation of parallel and serial operations in image processing.
III. Elaboration of principles of building hybrid (analog-digital and optical-electronic) image processing systems based on new hardware.
IV. Development of principles of using information redundancy of signals of images to raise processing throughput and save on hardware.

BIBLIOGRAPHY

1. Yaroslavskiy, L. P., RADIOTEKHNIKA, No 10, 1977.

2. "Aerokosmicheskiye issledovaniya zemli. Obrabotka videoinformatsii na EVM" [Aerospace Surveys of Earth. Computer Processing of Video Information], Moscow, 1978.

3. "Algoritmy i programmy obrabotki videoinformatsii VTs SO AN SSSR" [Algorithms and Programs for Processing of Video Information, Computer Center, Siberian Branch, USSR Academy of Sciences], Novosibirsk, No 2, 1981.

4. Vas'kov, S. T.; Mamontov, G. M.; and Potashnikov, A. K.,"Skaniruyushchiye ustroystva na ELT vysokogo razresheniya" [High-Resolution CRT Scanners], Novosibirsk, 1978.

5. Kryutchenko, Ye. V.; Kuchin, Yu. M.; Rabin, B. M. et al., PRIBORY I TEKHNIKA EKSPERIMENTA, No 1, 1975.

6. Shkundenkov, V. N., in "Tez. dokl. Vses. konfer. 'Avtomatizatsiya nauchnykh issledovaniy na osnove primeneniya EVM'" [Theses of Papers from the All-Union Conference on "Automating Scientific Research by Using Computers," Novosibirsk, 1979.

7. "Tezisy dokladov I Vsesoyuznoy konferentsii 'Statisticheskiye svoystva mikrostruktur'" [Theses of Papers from 1st All-Union Conference on "Statistical Properties of MicroStructures"], Moscow, 1978.

8. (Endryus, G. and Inlo, L.), ed., "Using Digital Computers for Image Processing," Moscow, 1973.

9. (Wang, T.), ed., "Image Processing and Digital Filtration," Moscow, 1973.

10. Pratt, W. K., "Digital Image Processing," New York, 1977.

11. Rosenfeld, A. and Kak, A. S., "Digital Picture Processing," New York, 1977.

12. (Paulis, A.), "Theory of Systems and Conversions in Optics," Moscow, 1971.

13. (Van Tris, G.), "Theory of Finding Estimates and Modulation," Moscow, Vol 1, 1972; Vol 2, 1975; Vol 3, 1977.

14. Ahmed, N. and Rao, K. P., "Orthogonal Transformation for Digital Signal Processing," New York, 1975.

15. Yaroslavskiy, L. P., "Vvedeniye v tsifrovuyu obrabotku izobrazheniy" [Introduction to Digital Processing of Images], Moscow, 1979.

16. (Keysesent, D.), ed., "Optical Processing of Information," Moscow, 1980.

17. Vasilenko, G. I., "Golograficheskoye opoznavaniye obrazov" [Holographic Pattern Recognition], Moscow, 1977.

18. Groce, R. and Burton, G., RCA REV., Vol 32, No 12, 1971.

19. (Keyzan, B.), ed., "Achievements in Image Reproduction Technology," Moscow, Vol 1, 1978.

20. Gorelik, S. L.; Kats, B. M.; and Palatnik, L. N., TEKHNIKA KINO I TELEVIDENIYA, No 11, 1972.

21. Gorelik, S. L. and Kats, B. M., "Elektronno-luchevyye trubki v sistemakh obrabotki informatsii" [CRT's in Information Processing Systems], Moscow, 1977.

22. Gorelik, S. L.; Rozenoyer, V. Ya.; and Semenov, Ye. F., TEKHNIKA KINO I TELEVIDENIYA, No 8, 1980.

23. Krivopustov, A. I.; Pivovarov, V. T.; and Pogostkin, L. S., in "Avtomatizatsiya upravleniya i obrabotki informatsii" [Automation of Information Management and Processing], Leningrad, 1980.

24. Kozlov, A. A. and Nadokhovskiy, G. N., in "Voprosy avtomatizirovannoy obrabotki informatsii" [Problems in Automated Information Processing], Tomsk, 1978.

25. Kruglikov, S. V.; Naymark, S. I.; and Mukhopad, Yu. F., OBZORY PO ELEKTRONNOY TEKHNIKE. SER. 3, No 744, 1980.

26. Kulikov, V. V. and Pelevin, V. Yu., in "Tez. dokl. regional'noy konfer. 'Obrabotka izobrazheniy i distantsionnyye issledovaniya'" [Theses of Papers from the Regional Conference on "Image Processing and Remote Surveys"], Novosibirsk, 1981.

27. Shurna, R. I., "Issledovaniye optiko-elektricheskogo preobrazovatelya parallel'no-posledovatel'nogo deystviya dlya chitayushchego avtomata" [Study of Optical-Electrical Converter with Parallel-Serial Operation for an Automated Reader], Automated Abstracts of Candidate's Dissertations, Kaunas, 1972.

28. Golovkin, V. A., "Parallel'nyye vychislitel'nyye sistemy" [Parallel Computer Systems], Moscow, 1978.

29. Receves, A. P., IEEE TRANS. COMPUT., No 4, 1980.

30. (Oppenheim, E.), ed., "Application of Digital Processsing of Signals," Moscow, 1980.

31. Kronrod, M. A., in "Ikonika. Tsifrovaya golografiya. Obrabotka izobrazheniy" [Iconics. Digital Holography. Image Processing], Moscow, 1975.

32. Alyavdin, M. S.; Kats, B. M.; and Mikhelevich, Ye. G., TEKHNIKA SREDSTV SVYAZI. SER. "TEKHNIKA TELEVIDENIYA", No 5, 1979.

33. Gorelik, S. L.; Kats, B. M.; and Kivrin, V. I., "Televizionnyye izmeritel'nyye sistemy" [Television Measuring Systems], Moscow, 1980.

34. Zhuravlev, G. A. and Zagorskiy, M. Yu., in "Avtomatizatsiya upravleniya i obrabotki informatsii" [Automation of Information Management and Processing], Leningrad, 1980.

8545
CSO: 1863/54

UDC 681.3:519.2

AUTOMATED IMAGE PROCESSING (PART 2, BASIC CONCEPTS IN IMAGE PROCESSING THEORY)

Vilnius TRUDY AKADEMII NAUK LITOVSKOY SSR, SERIYA B: KHIMIYA, TEKHNIKA, FIZICHESKAYA GEOGRAFIYA in Russian No 3(136), 1983
(manuscript received 12 Mar 82) pp 105-109

[Article by S. E. Val'teris and L. P. Yaroslavskiy, Institute of Engineering Physics Problems of Power Engineering, Lithuanian SSR Academy of Sciences; USSR Academy of Sciences Institute of Information Transmission Problems]

[Text] 1. Introduction. The problems in developing automated image processing systems and elaborating image processing methods insistently require elaboration of theoretical concepts which could serve as a guide in the labyrinth of types of images and problems of processing and a design tool for synthesizing image processing methods and systems. These concepts must be based on the fundamental concepts of information theory, the concepts of a signal, message and recipient as well as the statistical treatment of decision-making and estimating parameters in processing.

The existing difference in approaches to image processing in solving various applications problems often leads to superfluous information being processed, complication of processing algorithms and unwarranted outlays in computing resources. In this connection, clear classification of the images themselves as media of information and their processing problems and facilities is required.

This article is aimed at defining the basic principles of the unified concept of image processing.

2. Problems of Image Processing

In contrast to classical image transmission problems, from the theoretical-information viewpoint, images in processing are viewed not as messages but as signals. The messages in the images are random parameters of individual details of the image or its general structure. Determining them is also properly the ultimate aim of processing. The specific meaning of these parameters and criteria of accuracy of their estimate are determined by the recipient.

One can identify three types of recipients of messages consisting in images: 1) collective (as in television, cinematography and polygraphy), 2) individual (human operator) and 3) automated machines. They differ substantially by processing criteria.

A collective recipient is characterized by moderate properties, in particular, moderate psychophysical visual properties. The essential feature of an individual recipient is the informal nature of processing criteria. In the case of an automated recipient, there are usually precise formal processing criteria. The lack of formal processing quality criteria for an individual recipient produces the need for interactive processing under user control.

Image processing problems can be divided into two major classes: I, basic and II, auxiliary.

Class I problems include: 1) automatic measurements and decision-making, and 2) improvement of visual quality (for a collective recipient) and preparation of images (for an individual recipient).

Class II problems include: 1)correction of distortions in image systems, 2) coding for data banks, and 3) visualization of information.

In processing, images should be considered elements of a statistical ensemble. Meaningfulness of the random factors which produce this ensemble is determined by what sort of information the images contain for the recipient.

3. Classification of Images

From the viewpoint of information content and structure, it is expedient to distinguish three classes of images: I, local-informational; II, structural-informational (textural); and III, mixed.

1. Local-informational images are those in which objects of interpretation and the background portion can be identified in accordance with the requirements of the problem which produces them. Examples are images of the earth's surface in space and aerial photography used for geologic decoding, X-ray and radiographic images in medical diagnostics and introscopy, etc. A statistical description of these images must be built separately for objects of interpretation and the background. In doing so, images with a determinate and random background should be distinguished. Processing should also be optimzed separately. In many problems, optimization has to be performed with a fixed background image, i.e. essentially optimization for a given image being processed. This leads to adaptive processing methods (adaptation to background).

A major subclass of local-informational images includes those with a determinate background. These are primarily images of artificial objects (documents, drawings, images processed in checking integrated circuits, etc.)

II. Structural-informational or textural images are those in which information content consists in particular macroparameters which describe the image as a whole. Textural images cannot be divided into objects of interpretation and the background portion. Examples are images obtained in analyzing microstructures in biology and materials technology, and satellite images of forest cover, agricultural land and the sea surface. For statistical description of textural images, it is natural to use classical methods and statistical models of the theory of random processes and fields. In doing so, parameters of these models can be treated as parameters to be estimated in image processing.

III. Mixed images have attributes of both local-informational and structural-informational images. These can include images for the processing of which requirements are imposed to define finer structural features or compute statistics of local features for identifying objects of interpretation from local-informational images. Such problems occur in analyzing local objects containing a rather large subset of image elements. By using segmentation of mixed images, one can convert to structural-informational images.

4. Mathematical Models of Images

As a function of the image processing problems, one has to select suitable mathematical models of the very images of both the input signal of the processing operator and the processing operator as well as the quantitative criteria conforming to the processing process. For the subclasses of basic and auxiliary processing problems listed above, one can identify the following three groups of mathematical models of images [1, 2]:

1. Models of expansion in terms of a full set of orthonormed functions including traditional fast discrete orthogonal transforms (Fourier, Haar, Walsh-Adamar, Adamar-Haar transforms and various modifications of them, discrete sine and cosine fast transforms and others).

2. Autoregression models and models of status, the need of application of which occurs in developing algorithms for processing ensembles of images. An ensemble of images in these models is considered to be formed by a linear system when noise or a random series with a known function of spectral density is input. With line-by-line image processing (raster scanner) without regard to interline relations, images are represented as a set of unidimensional stochastic processes. The models are used in problems of coding, recursive filtration, restoration, etc.

3. Two-dimensional linear prediction models, in which a statistical interrelation of individual image point brightness is used and an estimate of brightness is generated for a point as the linear combination of brightness of preceding points. The models are used in differential coding, estimation, restoration and filtration of images [3].

In these models, images are represented as arrays of numbers described as vectors or matrices, which is common for any two-dimensional signals. But typical for data arrays representing images are features from which one can

identify the following: a) limited precision of representation of brightness (density) of a point stemming from the methods of obtaining source data and capabilities of visual representation (limited word length of array element); b) necessity of rather large quantity of points for perception of an image as a unit which causes the inevitability of recording, processing and visualizing large data arrays (large dimension of arrays); and c) presence of rather large subsets of identical values of brightnesses (densities) in data arrays, caused by structural features of images and limited word size of elements (information redundancy of arrays).

From these features, it follows that this representation is not optimal both in the sense of use of memory resources and in processing efficiency.

Another method of representing images which stems from the specific structure of an image as an information signal is its representation as word (bit) cuts. Word cuts in turn may be considered binary images consisting of ones and zeroes. The set of binary images forms some spatial structure of an image, quantized by levels, which allows performing processing at any word size level and parallel processing for all levels.

Development of algorithmic, software and hardware facilities for analysis of images represented by a spatial structure of bit planes may lead to substantial reduction in number of operations, processing time and information redundancy (see [3, 4]).

Let us illustrate some possibilities of formal descriptions of images at the bit plane level. Any subset S can be represented by the image fs which assumes the value of one for elements belonging to S and zero in the opposite case. For an N x N image, the description requires N^2 bits irrespective of the complexity of S. For simple subsets of S consisting of several elements, it is economical to represent the image as a list of their coordinates. Since each line of image fs consists of a variable series of ones and zeroes, it can be defined in terms of the length of the series by adding information on the feature of ones in a series in a line (ones or zeroes). Any subset is a combination of blocks of ones which can be defined by using indicators of the center and distances from the edge to the center or subset block boundary codes. Finally, by sequential division of an image into quadrants, one can obtain descriptions in the form of a quadrotree [4] or in the form of a pyramidal structure. All these descriptions use numbers of bits $<N^2$.

5. Conclusions

1. Problems in developing automated image processing systems require elaboration of theoretical concepts for image processing based on fundamental concepts of information theory.

2. Based on the theoretical-informational representation of an image as a signal to be processed, we should distinguish processing criteria as a function of type of recipient and classes of processing problems.

3. As a function of information content, it is advisable to divide images into three classes: local-informational, structural-informational and mixed.

4. Mathematical models for describing images are selected in accordance with processing problems. As a function of structure of images and concrete problems of processing, three models are distinguished: models of expansion in terms of a set of orthonormed functions, autoregression models and two-dimensional models for linear prediction.

5. Images, just as any two-dimensional signals, are represented in discrete form as arrays of numbers described as vectors or matrices. But typical of image data arrays are limited wordsize of elements, large dimension of arrays and their informational redundancy. The structure and features of image processing corresponds well to representation of images as word (bit) cuts.

BIBLIOGRAPHY

1. Yaroslavskiy, L. P., "Vvedeniye v tsifrovuyu obrabotku izobrazheniy" [Introduction to Digital Processing of Images], Moscow, 1979.

2. Jane, A. K., TR. IIER [IEEE Proceedings], Vol 69, No 5, 1981.

3. (Oppenheim, E.), ed., "Application of Digital Processing of Signals," Moscow, 1980.

4. Rosenfeld, A., TR. IIER [IEEE Proceedings], Vol 69, No 5, 1981.

8545
CSO: 1863/54

UDC 681.7.014.3:621.391

AUTOMATED IMAGE PROCESSING (PART 3, COMPUTER ARCHITECTURE FOR ELECTRONIC-OPTICAL AND DIGITAL IMAGE PROCESSING SYSTEMS)

Vilnius TRUDY AKADEMII NAUK LITOVSKOY SSR, SERIYA B: KHIMIYA, TEKHNIKA, FIZICHESKAYA GEOGRAFIYA in Russian No 3(136), 1983
(manuscript received 23 Mar 82) pp 111-123

[Article by S. E. Val'teris, S. L. Gorelik, Ye. A. Metlitskiy and L. S. Pogostkin, Institute of Engineering Physics Problems of Power Engineering, Lithuanian SSR Academy of Sciences; USSR Academy of Sciences Institute of Information Transmission Problems]

[Text] 1. Introduction. The extreme importance of automating processes in solving image analysis and synthesis problems has determined the swift development of efforts on using computers for image processing. A broad range of specialists are now working on this problem, various image processing systems including computer hardware are being developed and have been developed, and interesting results have been obtained in a number of applied problems. All this allows stating that digital image processing (TsOIz) has now become a major field of computer applications fully of its own.

But in assessing the results achieved, we should mention that there are a number of problems which limit application of digital image processing methods and facilities in many practical problems. They stem primarily from even powerful general-purpose computers, having advanced multilevel memory, peripherals and high-speed processors, often being inadequate in throughput and equipment for real problems in digital image processing. Operations such as geometric transformation of an image, spatial filtration, detection and measurement of parameters of reference crosses, and conversions in a dynamic range take time measured in hours.

A substantial rise in image processing system throughput can be achieved by developing specialized (problem-oriented) hybrid computing systems which have the capability of analog processing of images in an I/O device and the appropriate architecture for the digital part of the system. For images

on photographic media, analog processing methods are based on electronic-optical conversions of reading and synthesizing apertures and rasters, and the use of a scanning cathode ray tube (CRT) enables analysis of photographs with a number of elements up to 5×10^7 and with coordinate distortions not exceeding $(1 - 3) \times 10^{-5}$ from size of frame [1-4].

A typical feature of the majority of algorithms for digital image processing is a high degree of parallel processing. This matches the current general trend of developing hardware with parallel processing of information. According to current forecasts, parallel hardware in the near future (1985-1990) will reach 10^9 operations per second in throughput [5]. In image processing, hardware with suitable (parallel) architecture may have a throughput/cost ratio of two orders higher than a large computer with serial operation [6].

This article is aimed at analyzing the possibility of developing a hybrid system based on an electronic-optical processor, its functional structure and the architecture of a computer system for digital image processing.

2. Electronic-Optical Conversions

In a translucent CRT I/O device as part of a scanning transducer, operations for spatial linear and nonlinear filtration and geometric transforms can be implemented.

In spatial filtration, electronic-optical conversions of the reading beam are used. In doing so, the read aperture at each addressed image point is serially converted by an algorithm specified by an expansion mode control unit. In the video signal processing unit, the arithmetic-logic unit, signals can be subjected to linear or nonlinear operations as a function of synthesized filter type [7].

In general form, spatial filter response at an image point with coordinates $x_k = k_x h_x$, $y_k = k_y h_y$ is expressed by the relation

$$U(k_x k_y) = F\{f_j(U_j)\} \qquad (j = 1, 2, \ldots, n). \tag{1}$$

where: h_x, h_y are the scan digitizing steps on the x and y axes, respectively, k_x is the number of elements of expansion along a line, k_y is the number of the line from which the reading is taken, F is the statement defining the filter type (function of n- variables), f_j is some function of one variable, j is the ordinal number of the elementary aperture, and U_j is the response of the j-th elementary aperture, and

$$U_j = \int_{-\alpha}^{\alpha} \int_{-\alpha}^{\alpha} \rho_j(a_0, a_1, \ldots, a_m, x - k_x h_x, y - k_y h_y) B(x, y)\, dx\, dy, \qquad (2)$$

where: $\rho_j = (a_0, a_1, \ldots, x - k_x h_x, y - k_y h_y)$ is the distribution of intensity in the j-th elementary aperture, a_i ($i = 1, 2, \ldots, m$) are the distribution parameters, and B(x, y) is the image being processed.

The distribution of intensity ρ in an elementary aperture is determined by the combined effect of CRT and optical system scattering, and in the more general case, by the type of photoelectronic converter. One of the best approximations of the functions of ρ takes the form

$$\rho = \rho_0 \exp(-\bar{x}^2/\alpha_x^2 - \bar{y}^2/\alpha_y^2), \qquad (3)$$

where: $\bar{x} = (x - \Delta x)\cos\varphi + (y - \Delta y)\sin\varphi$, $\bar{y} = (x - \Delta x)\sin\varphi + (y - \Delta y)\cos\varphi$, ρ_0 is the brightness, α_x, α_y are the dimensions of the section in the general case of elliptic aperture, ϕ is the angle of orientation and Δ x, Δ y are the shifts relative to the beginning position.

Expression (3) well approximates the actual distribution in the case when the aperture size differs little from the size corresponding to optimal focusing. In the case when this condition is not met in at least one direction and the size becomes considerably larger than minimal (for CRT types 13LK16A, 13LK16L, 13LK18A and 18LK21L and those similar to them with a four- to five-fold gun), the distribution in the indicated direction becomes closer to rectangular:

$$\rho = \rho_0 \exp(-\bar{x}/\alpha x^2) R(\bar{y}), \qquad (4)$$

$$R(\bar{y}) = \begin{cases} 1 \text{ when } -\alpha/2 \leq y \leq \alpha/2 \\ 0 \text{ when } |y| > \alpha/2 \end{cases}$$

Using more complex electronic lenses for aperture formation, one can obtain other distributions [3].

Thus, in the case in question, the function of ρ_j can be represented as

$$\rho_j = \rho(\{\rho_0, \alpha_x, \alpha_y, \varphi, \Delta_x, \Delta_y\}_j, x, y), \qquad (5)$$

where $\{\cdot\}_j$ is the set of values of parameters for the j-th elementary aperture.

The function $f_j(U_j)$ can be defined by inserting functional converters, switched when the value of j changes, of a function of one variable in either the video path or the CRT brightness control circuit.

Most often, the function $f_j(U_j)$ is defined as

$$f_j(U_j)=a_j U_j;\ f_j(U_j)=\begin{cases}1 \text{ when } U_j \geq U_{\text{n}},\\ 0 \text{ when } U_j < U_{\text{n}},\end{cases} \tag{6}$$

where U_{n} is the voltage level threshold being defined.

The function f_j can also determine the nonlinear conversions of dynamic range, for example, taking logarithms.

Statement F specifies the type of spatial filter, for example:

$$F=\sum_{j=1}^{n} f_j(U_j);\ F=\prod_{j=1}^{n} f_j(U_j);\ F=U_1 T(U_j);$$
$$F=U_1/T(U_j) \qquad (j=2,\ 3,\ \ldots,\ n), \tag{7}$$

where T is a function of (n-1) variables.

By description by the method in question, all possible spatial filters both linear and nonlinear are actually exhausted. By using linear filters, one can realize operations of low-frequency and high-frequency filtration in various directions, and identify contours (figs. 1a, b). In aerial photographs, there is usually a large number of boundaries or lines, the orientation of which is random. In this case, to best identify these boundaries, it is advisable to use an adaptive anisotropic filter, the orientation of which changes during scanning. Adaptation can be performed not only by angle, but also by other filter parameters: aperture size, and values of weight factors a_j.

Various apertures are used in nonlinear filtration. As a function of type of statement F and functions f_j and T_j, one can identify major objects against a background of minor ones with retention of high-frequency elements in the objects being identified, identification of minor details, smoothing of the background, etc. (figs. 1c, d).

Electronic-optical methods also allow implementing geometric transforms of images in parallel with the scanning process: correction of projective distortions occurring during photographing, correction of distortion of optical systems and the CRT deflection yoke, nonlinear scanning distortions, etc. (figs. 1e, f). Implementing geometric transforms by electronic-optical methods in the scanning process enables automatic interpolation of readings and does not require large memory and additional time [3].

3. Structure of Electronic-Optical System

The functional scheme (fig. 2) of a hybrid analog-digital electronic-optical computer image processing system is based on a generalized representation of the spatial filtration statement (1) and a parametric description of the geometric transforms as series. Specific features of translucent CRT scanning

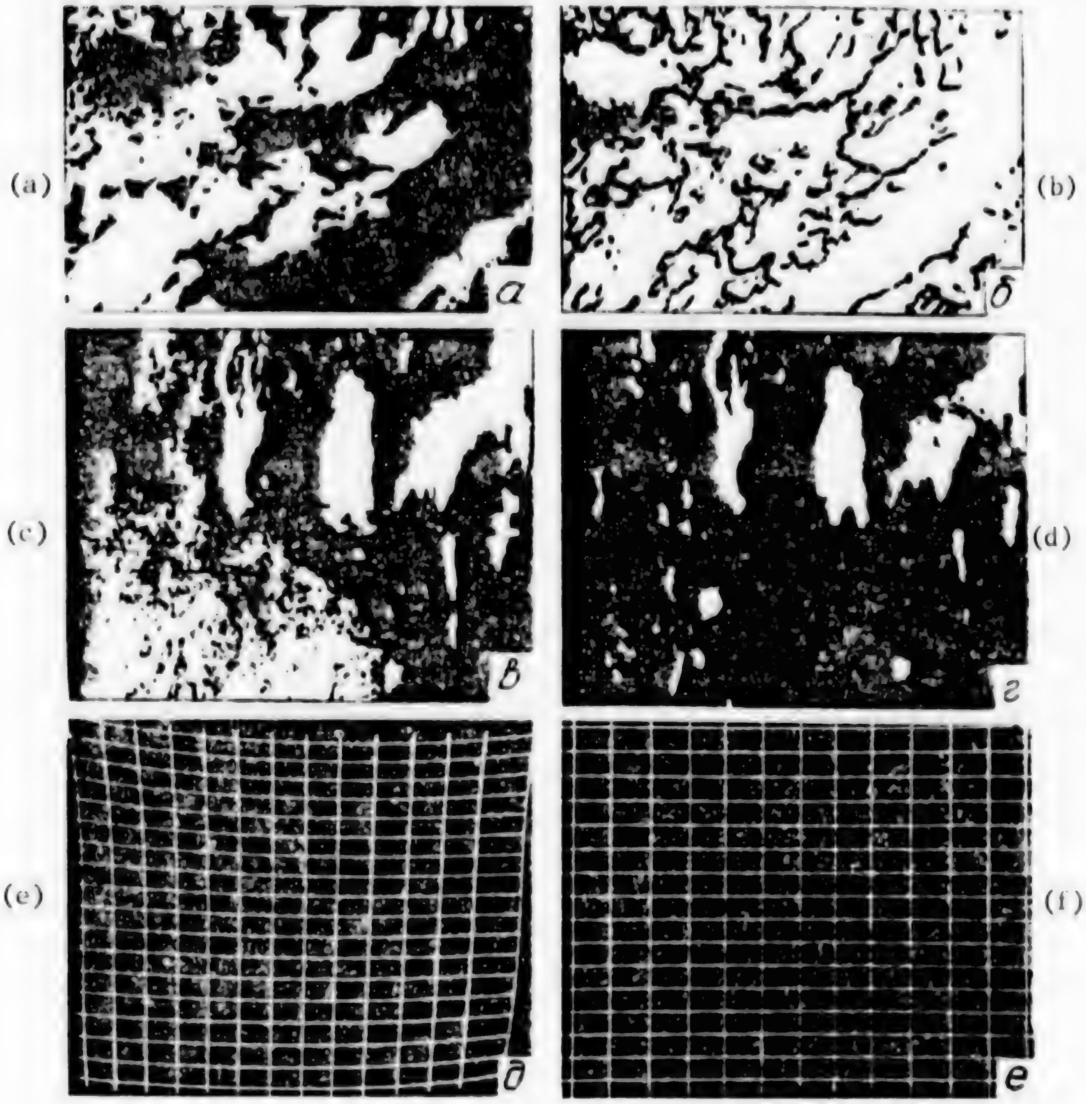


Fig. 1. Examples of electronic-optical conversions. Source (a, c, e) and converted images: b, by linear isotropic conversion for contour identification; d, by nonlinear pulse noise filtration; and f, by geometric transform.

transducers (system design with other light-signal converters is also possible) and requirements for accuracy of conversions typical of the majority of problems have also been taken into account [9].

In the system structure (fig. 2), several basic subsystems can be identified: the scanning transducer (SD) in which the scanned light aperture is formed, the optical-mechanical unit (OMB) which transfers the image of the scanned aperture to the photo image plane, replaces the photo image, and gathers the light flux which has passed through the photo image to the sensitive surface of the photoelectric converter (FEP); the analog-to-digital converter (ATsP);

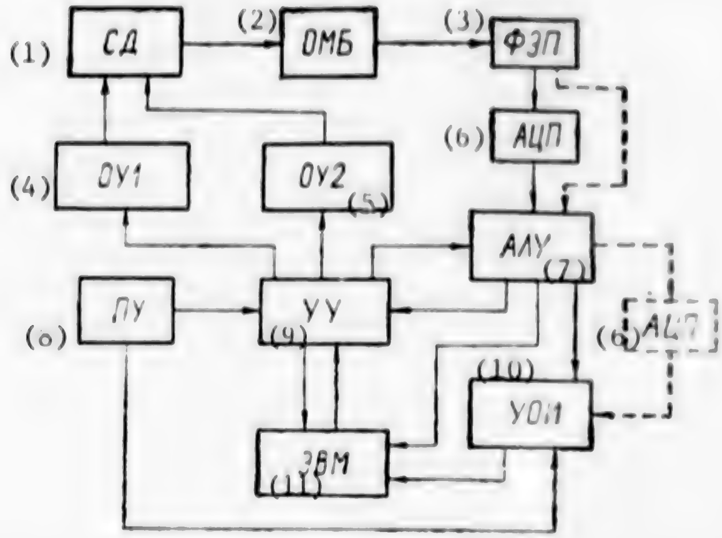


Fig. 2. Functional scheme of universal hybrid electronic-optical computer system

Key:

1. SD [scanning transducer]
2. OMB [optical-mechanical unit]
3. FEP [photoelectric converter]
4. OU1 [first operating unit]
5. OU2 [second operating unit]
6. ATsP [analog-digital converter]
7. ALU [arithmetic-logic unit]
8. PU [control console]
9. UU [control unit]
10. UOI [information display unit]
11. EVM [computer]

the first operating unit (OU1) which performs elementary operations (4); the second operating unit (OU2) which performs geometric transforms; the programmable arithmetic-logic unit (ALU) which computes spatial filter (1) parameters; the unit for controlling (UU) the operating and arithmetic-logic units; the control console (PU) for manual entry of parameters and processing modes; the information display unit (UOI) which contains a visual display, its own memory and photo recorder; and the computer for digital processing, decision making, pre-estimation of parameters, calibration, etc.

Shown in fig. 3 is a possible implementation of the functional schemes of a number of subsystems and the control and information signal paths. In the scanning transducer (SD) (fig. 3a), codes for currents to form the j-th aperture $(\Delta x_j, \Delta y_j, I_{1j}, I_{2j}, I_{3j})$ go from the OU1 [first operating unit] to the converter (BP) input, and the codes for the coordinates (x_n, y_n) go from the OU2 [second operating unit] to the distortion correction unit (BKI) input. The distortion correction unit generates the coordinate codes (x_{ck}, y_{ck}), corrected for the value of the geometric distortions, and the

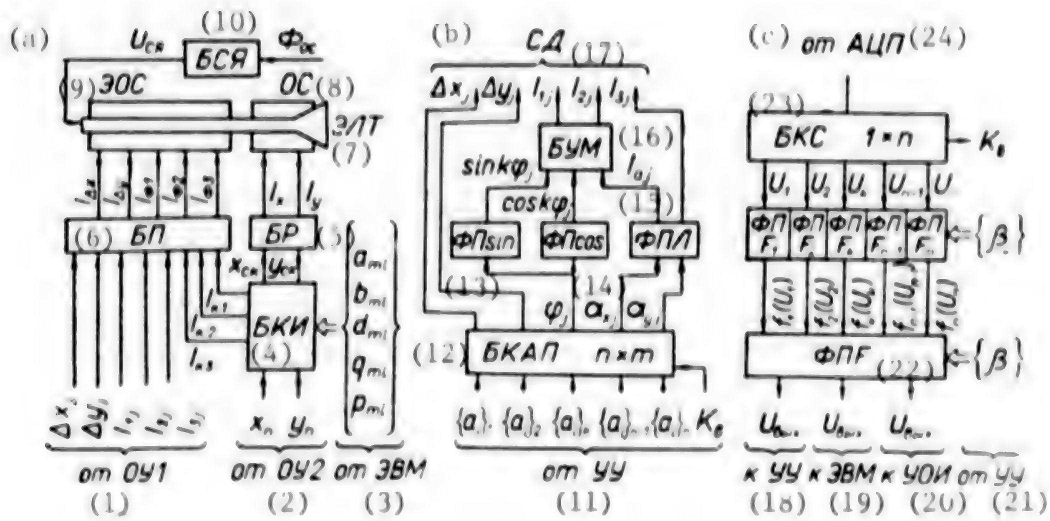


Fig. 3. Functional diagrams of main modules in electronic-optical computer system (a is the scanning transducer, b is the OU1 first operating unit and c is the arithmetic-logic unit)

Key:

1. from first operating unit
2. from second operating unit
3. from computer
4. BKI [distortion correction unit]
5. BR [scanner]
6. BP [converter]
7. ELT [CRT]
8. OS [deflection yoke]
9. EOS [electronic-optical system]
10. BSYa [not further identified]
11. from UU [control unit]
12. BKAP [aperture parameter switch]
13. FPsin [sine-cosine function converter]
14. FPcos [cosine-sine function converter]
15. FPL [linear converter]
16. BUM [multiplier]
17. SD [scanning transducer]
18. to UU [control unit]
19. to computer
20. to UOI [information display unit]
21. from UU [control unit]
22. FPF [F function converter]
23. BKS [signal switch]
24. from ATsP [ADC]

codes for currents to correct the basic spot aberrations (I_{k1}, I_{k2}, I_{k3}). Parameters for the distortion correction unit, $\{a_{ml}, b_{ml}, d_{ml}, g_{ml}, p_{ml}\}$, are determined in the process of calibrating the transducer (SD) and sent from the computer. The scanner (BR) generates the spot deflection currents (I_x, I_y) which go to the CRT deflection yoke. The scanner converts the codes for the currents to form the j-th aperture into control currents for the electronic-optical system $(I_{\Delta x}, I_{\Delta y}, I_{\phi 1}, I_{\phi 2}, I_{\phi 3})$ [1, 3]. Also effected in the unit is summing of the control and correcting currents:

$$I_{\phi 1} = I_{1j} + I_{k1};\ I_{\phi 2} = I_{2j} + I_{k2};\ I_{\phi 3} = I_{3j} + I_{k3}.$$

Currents I_{q1}, I_{q2} go to the windings for the paired quadrapole lens and current I_{q3} goes to the winding for the axial-symmetrical lens, while currents $I_{\Delta x}, I_{\Delta y}$ go to the winding for the dipole lens.

The information inputs for the operating control unit (UU) receive n sets of parameters $\{a_i\}_j$ of weight functions U_j for elementary filters (5) which go into designing the response of spatial filter (1). Upon control unit command K_B, the aperture parameter switch (BKAAP) selects the set $\{a_i\}_j$ for the elementary filter in the current processing

$$(a_{xj}, a_{yj}, q_j, \Delta x_j, \Delta y_j)$$

which goes to the units for functional conversion, sine-cosine and linear, and the multiplier (FPsin, FPcos, FPL, BUM) for construction of the functional relations [1]

$$I_{aj} = \psi_1(\alpha_{xj}, \alpha_{yj}), \quad I_{3j} = \psi_2(\alpha_{xj}, \alpha_{yj}), \qquad I_{1j} = I_{aj} \sin 2\varphi_j, \quad I_{2j} = I_{aj} \cos 2\varphi_j,$$

where: I_{aj}, I_{3j} are the codes for control current amplitudes to generate the current weight function in the SD [scanning transducer], and I_{1j}, I_{2j} are the codes for forming anisotropic apertures with a specified angle of orientation φ_j. Parameters for linear functional conversions are defined during calibration of the electronic-optical system (EOS) in the scanning transducer (SD).

The ALU (fig. 3c) input receives from the ADC the codes for the input image and the codes for the response of the elementary spatial filters U_j, equal to the convolution of the distribution of intensity in the j-th reading aperture. In the signal switch (BKS), upon control unit command K_B, the codes for response U_j of the j-th processing filter are sent to the corresponding input for the function converter unit (FPF). In the functional converters FPF_j, processing functions $f_j(U_j)$ (6) are computed for each of the elementary filters U_j. Output signals FPF $\{f_j(U_j)\}$ go to the functional converter for computation of the final processing result in accordance with the real statement $F\{f_j(U_j)\}$ (1).

Parameters for the functional conversions $\{\beta\}$, performed by the ALU, are defined either in the interactive mode by the operator at the stage of preprocessing of the image fragment to be investigated or as a result of synthesis of parameters for the spatial filter in the computer from conditions of the problem to be solved [9].

This electronic-optical image processing system operates in two modes: semiautomatic or automatic. In the semiautomatic (interactive) mode, the operator uses the control console to initiate the processing program in the UU [control unit].

4. Features of Digital Representation and Processing of Images

An image in digital form is represented as a two-dimensional array of numbers. Establishing the correspondence between the concepts of an "image element" and a "number" was taken into account in the digital representation of images in computers. Here in the majority of cases, there is a scheme of correspondence between an "image element (number)" and a "data element (machine word)." General-purpose computer processors are built to process data in the format of a machine word. The word length of image elements, in any case in certain stages of image processing, is considerably less than the customary formats for number representations. When a full-word processor is used in this case, a considerable portion of its component processor elements operates with zeroes. This is processing redundancy at the operating level.

Another type of processing redundancy shows up in representing a multishade (halftone) digital image as a set of bit cuts (RSr). Let P be an image represented by an N x N matrix of samples $P = \{p_{ij}\}$ (i j = 1, 2, ..., N), and p_{ij} is an integer from the range $[0, 2^r - 1]$, r > or = 1. Then P is represented as

$$P = 2^0 P_0 + 2^1 P_1 + \ldots + 2^{r-1} P_{r-1} = \sum_{l=0}^{r-1} 2^l P_l, \qquad (8)$$

where P_l are the bit cuts that can be considered as binary N x N images.

Fig. 4 shows a fragment (256 x 256) of a halftone image and its representation in the form of bit cuts (P_5, P_4, P_3) when r = 6. Note the presence in the majority of bit cuts of considerable areas which are completely zeroes or ones. This structural information feature is not considered in any way in processing. This leads to some processor resources being wasted on executing trivial operations on completely zero or one operations.

There is also processing redundancy at the algorithmic level. Let $P = \{p_{ij}\}$ (i = 1, 2, ..., N) undergo a nonlinear element-by-element transformation T_a, as a result of which a new image $P' = \{p'_{ij}\}$ (i = 1, 2, ..., N) is obtained, i.e. $p'_{ij} = T_a(p_{ij})$ for all i, j.

The direct way of implementing this transform requires N^2-fold computations of the function $T_a(p_{ij})$. Among these N^2 computations of the function $T_a(p_{ij})$ will be many that are repeated since for a real digital image, p_{ij}, as a rule, is an integer from the range $[0, 2^r - 1]$, while in the primary representation of the images, r is rarely greater than 8. Hence, it

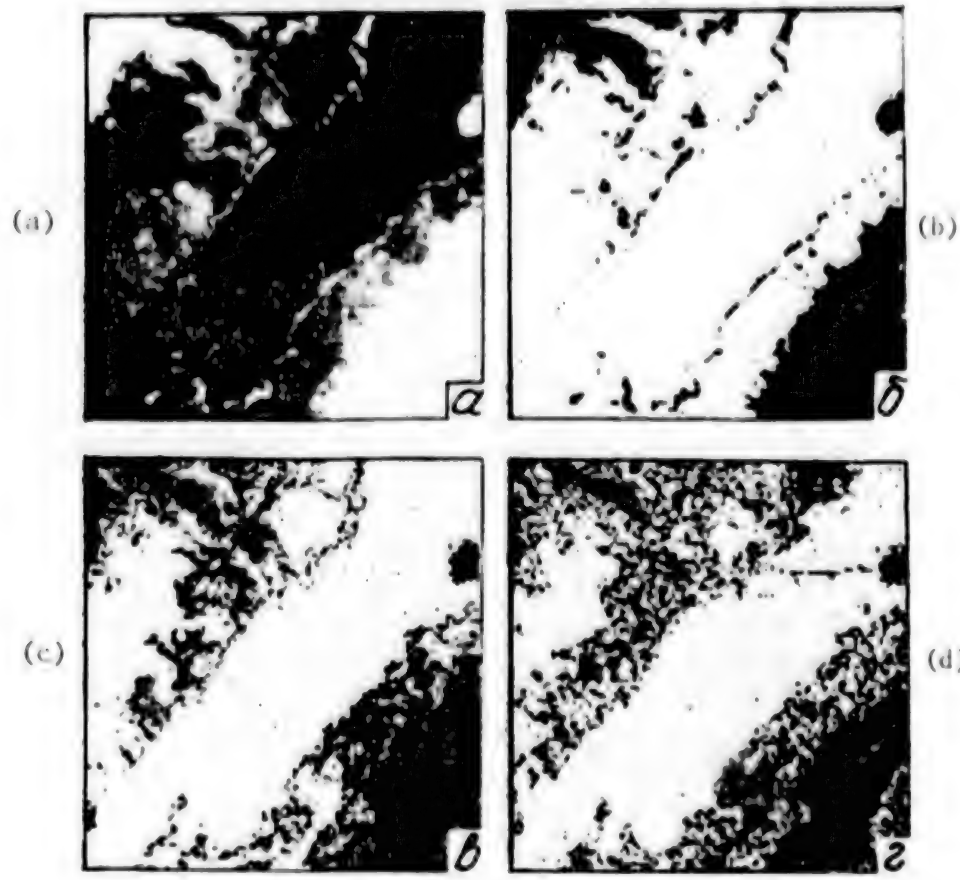


Fig. 4. Example of isolating bit cuts. Source image (a) and its bit cuts (b -- P_5, c -- P_4 and d -- P_3)

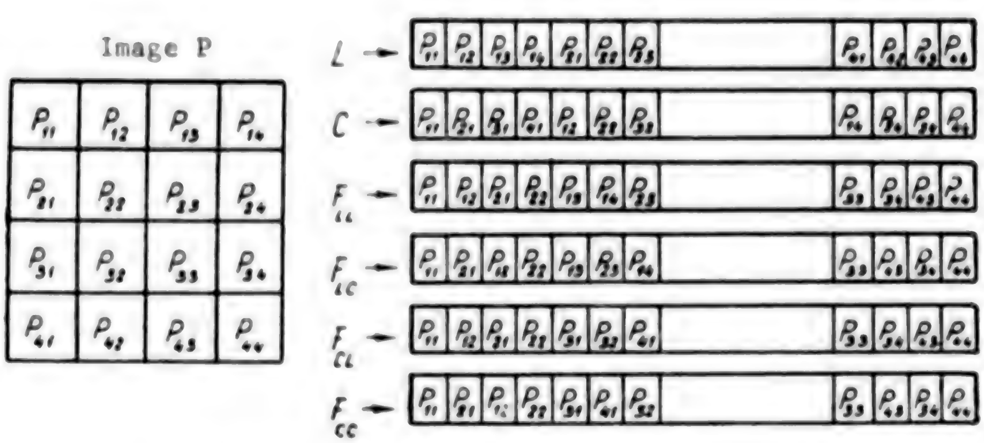


Fig. 5. Alternatives in mapping P to linear memory by lines (L), columns (C) and fragments (F_{LL}, F_{LC}, F_{CL}, F_{CC})

follows that N^2 elements of P may have any of $R(R = 2^r)$ values of brightness codes. This means potentially there is the possibility of executing not N^2, but R transforms of $T_a(p_{ij})$. In real problems, $R \ll N^2$ and the ratio N^2/R may take on a value on the order of 2^8-2^{12}. Thus, an N^2/R-fold increase in throughput may be obtained in the problem in question with appropriate data access organization in special structures of memory and the processor.

Let us consider a digital image P (fig. 5), represented as a two-dimensional array of numbers. Used in serial computing processes as a function of the processing algorithms are various forms of serial access to elements in this array. Shown in fig. 5 are the three main alternatives for mapping the array P to linear memory: in the form of L, by lines; C, by columns; and F, by fragments. In the latter case, various types of data ordering are possible in jumping from fragment to fragment and within each of them: F_{LL}, fragments are ordered in the direction of lines and elements in each fragment are ordered by lines; F_{LC}, same, except that elements are ordered by columns; F_{CL}, fragments are ordered in the direction of columns and elements in each fragment by lines; F_{CC}, same, except that elements are ordered by columns. For this example (a 4 x 4 image), the ways of organizing data in form F considered are exhaustive, but as array size increases, the number of alternatives increases rapidly.

In the majority of modern computers, memory device structure provides for address access to data elements. In doing so, the problem of converting from one organizational form to another is solved by calculating the corresponding addresses of the elements. In the simplest case, when all processing is effected in the same form of representation and data in memory are ordered the appropriate way, organizing access to it requires no substantial cost. But in the majority of problems in various stages of image processing, we operate with different forms of data organization. A typical example here is the problem of a two-dimensional array (data in forms L and C). In this case, even disregarding problems of exchange with external storage units, costs for calculating data element addresses can be quite considerable.

Each element in digital image P is represented by some series of ones and zeroes. At the most detailed level, information on the image is a three-dimensional bit structure (fig. 6). Adding the third dimension (Q) allows considering additional data organizational forms. These are primarily bit cuts (RSr) and bit layers (RSl) of a digital image. A bit layer is formed by a set of bit cuts (fig. 7). The bit cut and layer forms have a value of their own since there is a special class of image processing algorithms operating with such data structures [10, 11].

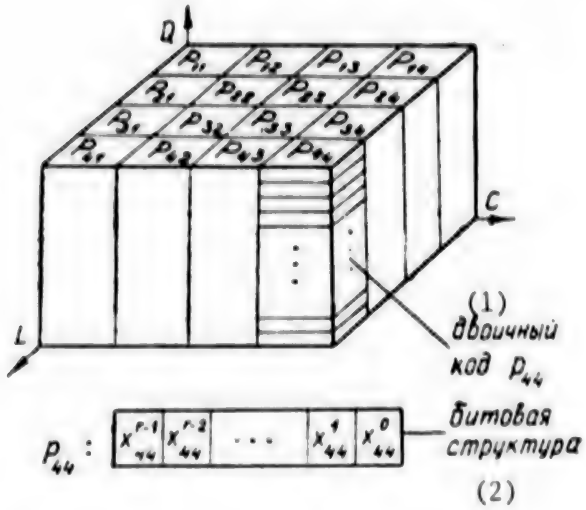


Fig. 6. Bit structure of array of data P_{ij}

Key:
1. binary code for P_{44} 2. bit structure

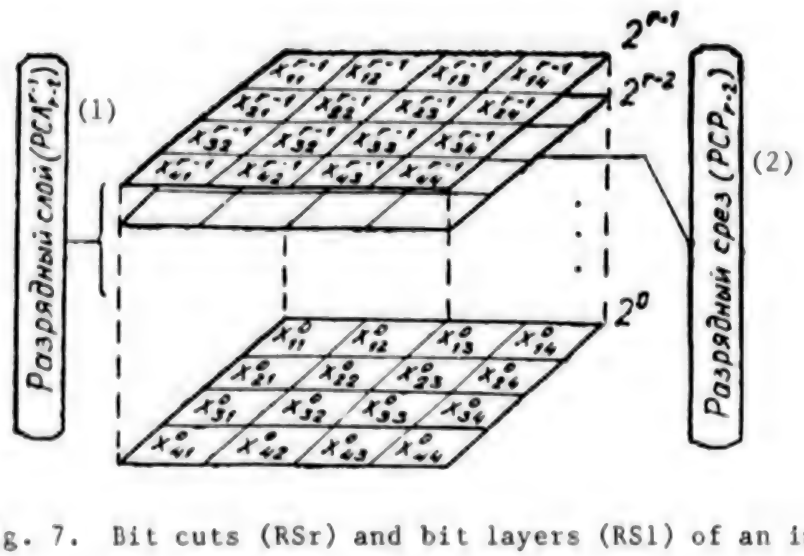


Fig. 7. Bit cuts (RSr) and bit layers (RSl) of an image

Key:
1. bit layer (RSL^{r-1}_{r-t}) 2. bit cut (RSR_{r-2})

Let us now consider the problem of memory structure in which the capability of accessing data in all the forms described above could be implemented. Let us consider multiblock memory with blocks of N x N x 1 bits. This block, oriented on the bit cut plane allows storing N^2 bits of bit cuts, while a pack of r blocks stores an image in the form shown in fig. 7. With this memory organization, access to an image element (number) is afforded by the capability of simultaneous access to all blocks.

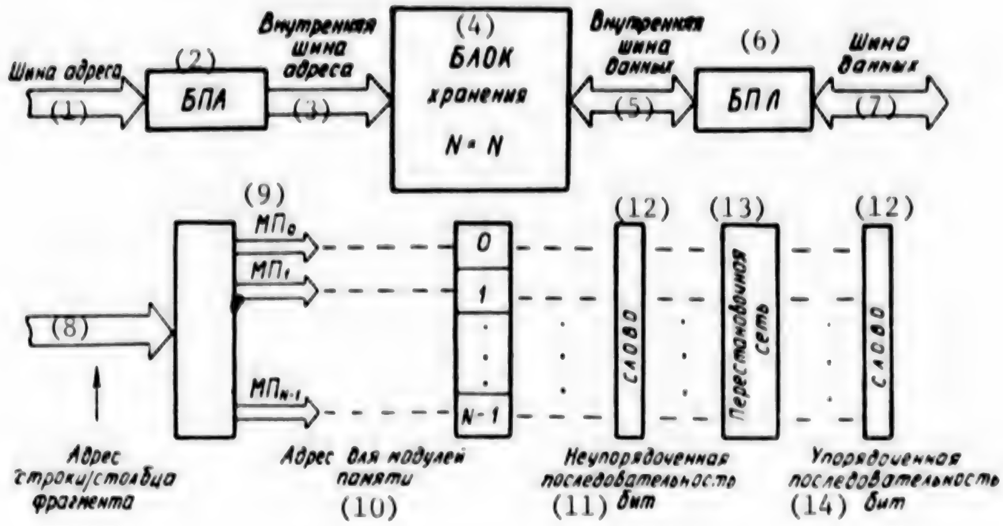


Fig. 8. Structure of memory block with parallel multidimensional access

Key:

1. address bus
2. BPA [address conversion unit]
3. internal address bus
4. storage block N x N
5. internal data bus
6. BPD [data conversion unit]
7. data bus
8. fragment row/column address
9. MP [memory modules]
10. address for memory modules
11. unordered series of bits
12. word
13. rearrangeable network
14. ordered series of bits

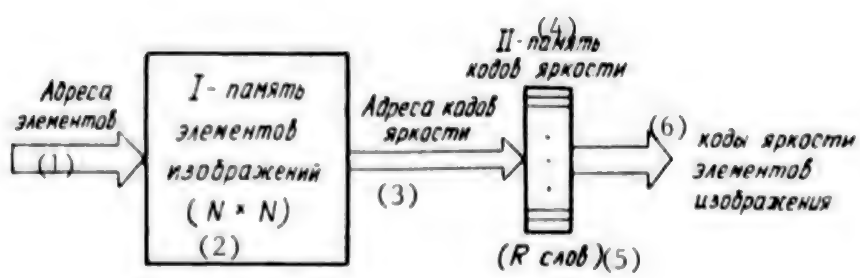


Fig. 9. Structure of memory block with indirect addressing

Key:

1. element addresses
2. I - image element memory (NxN)
3. brightness code addresses
4. II - brightness code memory
5. (R words)
6. image element brightness codes

In the memory block structure with parallel and multidimensional (L, C, F) data access (fig. 8), a special role is played by the address (BPA) and data (BPD) conversion units. They afford proper addressing and ordering of data when distributions of elements of bit cuts by memory modules are used in a storage block. Based on the described principles of organization of N x N x 1 memory blocks, a device (image storage unit) that affords very flexible capabilities for operating with data can be designed.

Another memory structure can be derived by introducing indirect addressing for the value of the image element brightness code (fig. 9). In such memory, the problem of associative (in content) access to data is partially solved. Thus, for example, simultaneous processing of all digital image elements having equal brightness code values is possible. This means any point-by-point conversion of an image can be performed not with N^2 elements of memory I, but with R elements of memory II.

One can expect that these principles of multidimensional parallel access and indirect addressing of data will be combined in future memory systems in computer systems for digital image processing.

5. Processor Architecture

Efforts on developing specialized computer systems for digital image processing have been underway now for more than 20 years. Several approaches to the problem have been formed in this time. Three different directions in this field can now be identified.

1. Development of built-in processors with a rigid structure oriented to solving a specific problem. Such processors handle some particular problems in systems using non-digital methods and means of processing, for example, in the electronic-optical systems for image analysis presented in this article.

2. Design of image processing systems based on powerful single-processor, multiprocessor, array and other types of parallel computing structures. Specialization of such systems is achieved mainly by developing special image I/O peripherals and the appropriate software [12].

3. Development of special processors specially oriented to image processing. Most typical representatives of this direction are systems with a cellular-array structure of the parallel processor having a rigid or reconfigurable network of connections between processor elements (PE) and using maximally simple single-bit logic element processors.

The first direction is outside the scope of this work. As for the second and third, several arguments for developing specialized parallel processors for digital image processing were advanced above and the following can be added.

Typical image processing problems belong to the class of problems lending themselves well to parallel processing which allow parallel processing of multiple data streams. The number of processors in a parallel processing

system determines the increase in its throughput, but increasing them causes an increase in system complexity and cost. Striving for the maximum possible degree of parallel processing would require developing a system in which the number of processor elements is commensurate with the number of image elements. Also, in cellular-array structures, image processing is effected in bit planes, bit cuts, which makes eliminating operating redundancy in processing fundamentally possible.

A description of various alternatives for array bit processors (MBP) for image processing is given in [10, 11]. Common to all is that the array is made up of single-bit processor elements, each of which through input logic effects a link to the "neighborhood" in the tetra-, hexa- or octagonal lattice. Analysis of the neighborhood in processing binary or bit cuts of half-tone images is the same necessary operation as any computer operation executed by processor elements on bit cut elements.

6. Conclusions

1. The main shortcoming in image processing systems based on general-purpose computers is inefficiency in solving processing problems due to the mismatch between computer system structure and the information structure for digital representation of images. This causes bit and operation redundancy in processing and requires a large amount of memory and machine time.

2. A substantial increase in image processing system throughput can be achieved by developing hybrid computer systems which implement a series of operations by a processor for analog processing and which have a parallel structure in the processor for digital processing.

3. Based on electronic-optical methods for controlling reading aperture parameters, a serial-parallel processor can be built for image input and processing which has better throughput compared to digital systems, and more flexibility and universality than optical-digital systems.

4. In designing processors for digital processing of information oriented to image processing, parallel processors with maximally simple single-bit processor elements and a reconfigurable link between them should be used.

These general principles of architecture for specialized computer systems for image processing closely related to methods and algorithms for image processing are the basis for designing concrete systems which make efficient use of the capabilities of the element base and computer hardware.

BIBLIOGRAPHY

1. Gorelik, S. L. and Kats, B. M., "Elektronno-luchevyye trubki v sistemakh obrabotki informatsii" [CRT's in Information Processing Systems], Moscow, 1977.

2. Vas'kov, S. T.; Mamontov, G. M.; and Potashnikov, A. K., "Skaniruyushchiye ustroystva na ELT vysokogo razresheniya (dlya EVM)" [High-Resolution CRT Scanners (for Computers)], Novosibirsk, 1978.

3. Gorelik, S. L., BRE. SER. "TEKHNIKA TELEVIDENIYA", No 3, 1978.

4. Gorelik, S. L.; Kats, B. M.; and Palatnik, L. N., TEKHNIKA KINO I TELEVIDENIYA, No 11, 1972.

5. Golovkin, B. A., "Parallel'nyye vychislitel'nyye sistemy" [Parallel Computer Systems], Moscow, 1980.

6. Gaerther, W. W.; Patel, M. P.; Reddi, S. S. et al., in "Proc. Int. Conf. on Parallel Processing," New York, 1976.

7. Gorelik, S. L.; Rozenoyer, V. Ya.; and Semenov, Ye. F., TEKHNIKA KINO I TELEVIDENIYA, No 8, 1980.

8. Gorelik, S. L.; Kats, B. M.; and Kivrin, V. I., "Televizionnyye izmeritel'nyye sistemy" [Television Measuring Systems], Moscow, 1980.

9. Pogostkin, L. S., "Algoritmy i programmy obrabotki videoinformatsiy" [Algorithms and Programs for Processing Video Information], [Novosibirsk], No 2, 1981.

10. Preston, K; Duff, M. J. B.; Lev'yal'di, S. et al., TR. IIER [IEEE Proceedings], Vol 67, No 5, 1979.

11. Duff, M. J. B., in "3rd Int. Joint Conf. on Pattern Recognition," New York, 1976.

12. "Proc. 1975 Samagor Computer Conf. on Parallel Processing, New York, 1975.

8545
CSO: 1863/54

SOLAR-POWERED ELEKTRONIKA MK-60 MICROCALCULATOR

Moscow EKONOMIKA SEL'SKOGO KHOZYAYSTVA in Russian No 12, Dec 83 p 33

[Text] The sun is being converted to numbers--the Elektronika MK-60 microcalculator is powered from it or from the light of an electric lamp. Designed to perform the simplest calculations, it will be a good assistant in the home.

It performs four arithmetic operations, it changes the signs of numbers, it operates with percent and memory, it extracts square routes and it corrects erroneously entered numbers. The display is an eight-digit liquid crystal type. The power supply is solar cells. The dimensions are 115 X 65 X 8 mm and the price is 50 rubles.

6521
CSO: 1863/114

UDC 681.326.35

QUALITATIVE ANALYSIS OF SPATIALLY DISTRIBUTED SYNCHRONIZERS

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83
(manuscript received 15 Jul 83) pp 16-18

[Article by Gennadiy Ivanovich Lamanov and Vyacheslav Ivanovich Smolin,
Scientific Research Institute of Control Computers, Leningrad]

[Text] The universal attention toward multiprocessor complexes (VK) as a means of increasing the viability of computer systems [1] led to the need to solve the problem of synchronization of spatially distributed multiprocessor complexes. Solution of the given problem within the framework of SM EVM [international small computer system] is related to development of a spatially distributed synchronizer [2], which consists of a set of elementary synchronizers (ES). Each elementary synchronizer is located in the device to be synchronized by it, while the joint operation of the elementary synchronizer is determined by a single functional algorithm of the entire multiprocessor complex.

Since the operating quality of the multiprocessor complex as a finite automaton is determined not only by its working algorithm and by the component base used, but also by the quality of formation of the working time intervals, the problem of estimating the quality of synchronizers by the functional criterion, insufficiently revealed in known literary sources, arises.

A block diagram of the basic model of the synchronizer, the operation of which is based on known principles of generation, shaping, transmission and multiplication of synchronous pulses by using a master oscillator (ZG), a reference pulse shaper (FI), a synchronous pulse shaper (FE) of the discreteness of the time ratios of the phases, a synchronous pulse phase shaper (FF), synchronous pulse transmitters and receivers (PDS and PRS), communication lines (LS) and a synchronous pulse multiplication circuit (SR) is shown in Figure 1.

The synchronous pulses are deformed during shaping and transmission, as a result of which their time parameters produce a defect in the form of scattering of the delays of the fronts to be shaped at each shaping stage. Thus, the time instability of the given synchronizer model comprises:

$$\Delta t = \max\left[\sum_{i=1}^{n}[t_{\max} - t_{\min}]_i\right]_{ik} \leq \Delta t_{\max},$$

where $i \in \{1, 2, ..., s\}$, $j \in \{1, 2, ..., n\}$, $k \in \{1, 2, ..., \rho_i\}$, s is the number of shaped phases, n is the number of shaping stages and synchronous pulse transmission, ρ_i is the number of phase multiplication branches i and Δt_{max} is the maximum permissible time instability.

On the other hand, the synchronizer under consideration has the load capacity

$$N = \sum_{i=1}^{s} \sum_{k=1}^{\rho_i} N_{ik} \geqslant N_{min},$$

where N_{ik} is the load capacity of the output k of phase i and N_{min} is the minimum required load capacity of the synchronizer.

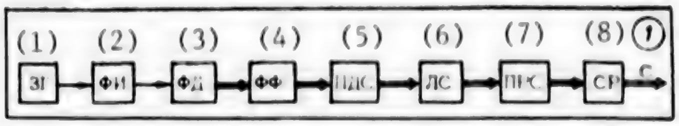


Figure 1

Key:
1. Master oscillator
2. Reference pulse shaper
3. Synchronous pulse shaper of discreteness of time ratio of phases
4. Synchronous pulse phase shaper
5. Synchronous pulse transmitter
6. Communication line
7. Synchronous pulse receiver
8. Synchronous pulse multiplication circuit

The synchronizer reads the time intervals, relying on which the logic devices to be synchronized by them realize the algorithm for their own operation. Therefore, the accuracy of shaping the time intervals is the most important characteristic of any synchronizer. But the given characteristic should be realized with compulsory fulfillment of conditions on the load capacity of the synchronizer, which excites a specific number of inputs of the logic device with given energy consumption. Since the load capacity of the synchronizer multiplication circuit and the accuracy of shaping the time intervals are in opposition, the expression for determination of the functional quality of the synchronizer can be represented in the form

$$Q = B\left[D \sum_{i=1}^{s} \sum_{k=1}^{\rho_i} N_{ik} / \max \left[\sum_{j=1}^{n} \Delta t_j\right]_{ik}\right], \quad (1)$$

where B is the coefficient of reduction of quality to the required readout system and D is the coefficient of the relative weight of both parameters.

For example, if the unit of measurement of quality Q should be equal to the amount of the load per second, then coefficient B should be equal to 10^{-9} when measuring N_{ik} by the number of units of inputs and when measuring Δt by

nanoseconds. Expression (1) permits one to analyze the quality of shaping and of the electrical transmission of the synchronous pulses in a spatially distributed multiprocessor complex with synchronous and asynchronous intermodule connections.

A block diagram of an elementary synchronizer for a multiprocessor complex with synchronous intermodule connections is presented in Figure 2.

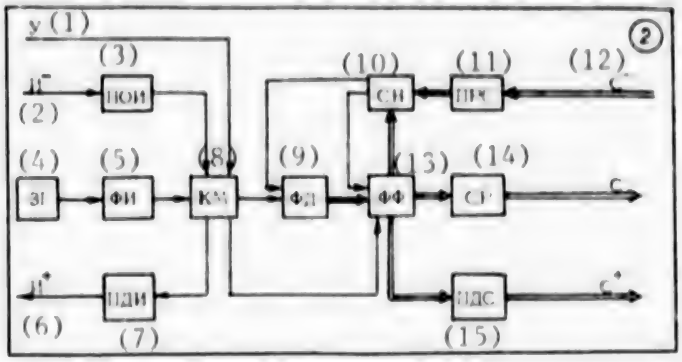


Figure 2

Key:

1. Input U
2. AND$^-$
3. Reference pulse receiver
4. Master oscillator
5. Reference pulse shaper
6. AND$^+$
7. Pulse transmitter
8. Commutator
9. Synchronous pulse phase shaper
10. Non-coincidence circuit
11. Synchronous pulse receiver
12. Systems input
13. Synchronous pulse phase shaper
14. Synchronous pulse multiplication circuit
15. Synchronous pulse transmitter

The commutator (KM) of a given elementary synchronizer is set at input U by the systems logic signal to the state for receiving reference pulses from the reference pulse shaper of the same elementary synchronizer or from the reference pulse shaper of the previous elementary synchronizer coming from the AND$^-$ input through the reference pulse receiver (POI).

The use of memory elements in the elementary synchronizer does not permit one to achieve synchronous operation of the synchronous pulse shaper of the discreteness of the time ratios of phases and of the synchronous pulse phase shaper without preliminary tuning. A non-coincidence circuit (SN) is introduced into the elementary synchronizer in this regard, which makes it possible to set the memory elements (flip-flops) of the indicated shapers of the given elementary synchronizer to the initial state upon non-coincidence of phases by its synchronous pulses with the synchronous pulse phases of the previous elementary synchronizer located in another logic module. One or several synchronous pulse phases are fed from the previous elementary synchronizer to the non-coincidence circuit through the synchronous pulse receiver connected to the systems input S^-. A similar set of synchronous pulse phases is fed from the given elementary synchronizer to the next synchronizer through the system synchronous pulse transmitter and system output S^+.

An additional delay element is introduced at the output of the commutator (KM) to compensate for the additional delay of synchronous pulses caused by the appearance of a chain of reference synchronous pulse transmission in the given model of the spatially distributed synchronizer. Introduction of this element results in an increase of the phase scattering of the synchronous series by the value

$$\Delta t_{д} = \sum_{\text{ЛП, ПОИ}}^{\text{П.Ш}} \sum_{\lambda=2}^{r} \Delta t_{\text{дmin}\lambda}, \tag{2}$$

where Δt_d is the additional instability of the synchronous pulses due to the reference pulse transmission channel, LP is the reference pulse transmission line and z is the number of elementary synchronizers in the spatially distributed synchronizer of a multiprocessor complex with synchronous intermodule connections at

With regard to expressions (1) and (2), the quality of a spatially distributed synchronizer of a multiprocessor complex with synchronous intermodule connections is described by the expression

$$\begin{cases} Q = B\,[DN_{\Sigma}/\Delta t], \\ N_{\Sigma} = \sum_{i=1} \sum_{k=1}^{r_i} \sum_{\lambda=1}^{r} N_{ik\lambda}, \\ \Delta t = \max\left[\sum_{j=1}^{6} \Delta t_j\right]_{ik} + \max\left[\sum_{\text{ЛП, ПОИ}}^{\text{П.Ш}} \sum_{\lambda=2}^{r} \Delta t_{\text{дmin}\lambda}\right]_{\lambda}, \end{cases} \tag{3}$$

where 6 is the number of stages of the synchronous pulse shaping channel.

A block diagram of an elementary synchronizer for a multiprocessor complex with asynchronous intermodule connections is shown in Figure 3.

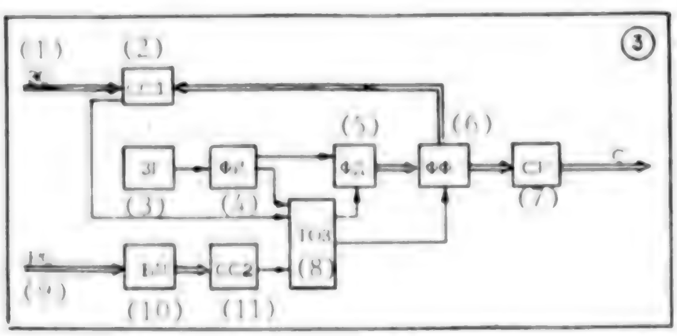


Figure 3

Key:

1. Forbid signal
2. Coincidence circuit 1
3. Master oscillator
4. Reference pulse shaper

[Key continued on following page]

[Key continued from preceding page]:

5. Synchronous pulse shaper of discreteness of time ratios of phases
6. Synchronous pulse phase shaper
7. Synchronous pulse multiplication circuit
8. Start-stop flip-flop
9. Resolving signal
10. Receiver unit
11. Coincidence circuit 2

As in the first case, a spatially distributed synchronizer contains r elementary synchronizers according to the number of logic data processing modules. The coincidence circuit (SS1) converts the start-stop flip-flop (TOZ) and through it the entire elementary synchronizer to the stop condition by the forbid signals (ZS) of completion of work of the given logic module and at a specific ratio of phases of the synchronous series ES of this same module. On the other hand, the start-stop flip-flop and elementary synchronizer are changed to the start condition by a set of resolving signals (RS) fed from the other z - 1 modules through the receiver unit (BP) and the coincidence circuit (SS2). The operation of the elementary synchronizer begins in this case from the stop phase of its synchronous series.

The scattering of the synchronous pulse delay in a spatially distributed synchronizer for a multiprocessor complex with asynchronous intermodule connections is determined only by the main synchronous pulse propagation circuit, while its load capacity is determined by the sum of the permissible loads z of the elementary synchronizer. Therefore, the quality of a synchronizer of given type, according to (3), is determined by the expression

$$\begin{cases} Q = B\,[DN_\Sigma/\Delta t], \\ N_\Sigma = \sum\limits_{i=1}^{s} \sum\limits_{k=1}^{r_i} \sum\limits_{\lambda=1}^{r} N_{ik\lambda}, \\ \Delta t = \max\left[\sum\limits_{j=1}^{5} \Delta t_j\right]_{ik}. \end{cases} \qquad (4)$$

where 5 is the number of stages of the synchronous pulse shaping channel.

Analysis of expressions (1), (3) and (4) permits one to conclude that the quality of spatially distributed synchronizers is higher than that of spatially concentrated synchronizers due to elimination of the PDS-LS-PRS transmission channel from the synchronous pulse shaping circuit (see Figure 1). A reduction of the depth of the pyramidal multiplication circuit of the synchronous series of elementary synchronizers (see Figures 2 and 3) due to a reduction of its load capacity also contributes to this. At the same time, the quality of a spatially distributed synchronizer for a multiprocessor complex with asynchronous intermodule connections is higher than the quality of a similar synchronizer for a multiprocessor complex with synchronous intermodule connections. This is the result of eliminating the additional load from the synchronous pulse shaping circuit. Moreover, a synchronizer of the latter type is more technologically effective due to the absence of an alternate delay element.

The use of the considered synchronizer models in ASVT [modular computer equipment system] and SM EVM multiprocessor complexes made it possible to convert from synchronous computers of the M6000 type to M7000 two-processor synchronous computers and to develop specialized multiprocessor complexes based on the SM-2 computer with asynchronous intermodule connections. In this case the quality of the synchronizers of the three enumerated computer generations, according to the considered method, increased from $Q_1 = 300\ s^{-1}$ for the M6000 and $Q_2 = 1,000\ s^{-1}$ for the M7000 to $Q_3 = 10,000\ s^{-1}$ for the SM-2 at $D = 1$.

BIBLIOGRAPHY

1. Trapeznikov, V. A., "Some Problems of Science in Development of Control Systems," PRIBORY I SISTEMY UPRAVLENIYA, No 2, 1981.

2. Gomon, L. V., I. I. Itenberg, G. I. Lamanov and A. R. Yakovlev, "Intermodule Connections in the SM-2 Computer Complex," PRIBORY I SISTEMY UPRAVLENIYA, No 12, 1979.

6521
CSO: 1863/104

ELEKTRONIKA CALCULATORS

Kiev PRAVDA UKRAINY in Russian 18 Nov 83 p 4

[Advertisement for Elektronika calculators by Moscow Industrial Combine for Commercial Advertising]

[Excerpt]

Programmable Micro-calculators for Complex Engineering and Technical Calculations

All models perform the arithmetic operations, operations with a constant, sign changes, operations with pi, operations with memory, and calculation of the functions: $1/x, \sqrt{x}, x^2, x^y$, lg x, ln x, e^x, 10^x; and trigonometric functions. Cathode luminescent display.

	B3-21	B3-34	MK-46	MK-56
Number of Memory Registers	7	14	7	14
Weight, kg	0.39	0.39	2.5	1.3
Dimensions, mm:				
length	185	185	310	240
width	100	100	270	205
height	43	47	90	55
Battery type	D055S	D055S	from wall	from wall
Price, rubles	80	85	235#	185#

Notes: # wholesale price

Micro-Calculators for Engineering and Technical Calculations

All models perform the four arithmetic operations, operations with a constant, sign changes, operations with pi, operations with memory, and calculation of elementary, power, exponential, logarithmic and trigonometric functions: x^y, $1/x$, $\sqrt{x}$, lg x, ln z, sin x, cos x, tg x, arc sin x, arc cos x, arc tg x.

	S3-15	B3-18M	B3-18A	B3-19M	B3-32	B3-35	B3-36	B3-37	B3-38	MK-41	MKSh-2
Calculations with ( )	*				*	*	*		*	*	*
Functions x^2					*				*		*
10^x			*		*	*	*	*	*	*	*
e^x	*	*	*	*	*	*	*	*	*		*
Factorial n!						*	*		*		
Display:											
cathode luminescent		*	*		*	*	*			*	*
light-emitting diode	*			*				*			
liquid-crystal									*		
Weight, kg	0.36	0.3	0.36	0.4	0.3	0.25	0.2	0.3	0.05	1.2	1.5
Dimensions, mm:											
length	172	170	160	166.5	120	143	172	155	55	212	250
width	91	86.5	90	86	73	79	78.5	78	91	175	180
height	32	26.5	46	41	30.5	22	17.5	28	5.5	75	78
Battery type	TsNK	A316	D0.55S	D0.55S	A316	D0.25	D0.25	A316	STs30	net	net
Number of batteries	4	4	4	4	3	4	3	4	2		
Price, rubles	110	45-60	46-72	65	65	65	70	55	70	180	60

Micro-Calculators for Simple Calculations

All models perform the arithmetic operations and operations with a constant.

	B3-14	B3-23	B3-24G	B3-26	B3-30	MK-33 S3-33	B3-39	MK-53	MK-57 MK-57A	MK-60##
Operations with %	*	*		*	*	*	*	*	*	*
Sign change				*		*				
Functions $\sqrt{x}$	*			*		*				
1/x	*			*			*	*	*	*
Operations with memory			*	*		*		*	*	*
Display:										
cathode luminescent	*			*						
light-emitting diode		*	*			*			MK-57	
liquid-crystal					*		*	*	MK-57A	*
Weight, kg	0.3	0.3	0.3	0.3	0.1	0.12	0.065	0.05	0.15	0.06
Dimensions, mm:										
length	125	155	155	142	110	132	110	95	155	115
width	74	78	78	80	66.5	71	66.5	60	78	65
height	31	28	28	27.5	10.5	14.7	10.6	6.9	28	8
Battery type	A316	A316	A316	A316	D0.06	D0.1	STs32	STs32	A316	SB-4
Number of batteries	3	3	3	4	2	4	3	2	3	
Price, rubles	35	25	35	35	40	35	40	60	35	60###

Notes: ## solar batteries; ### preliminary price

8545
CSO: 1863/82

ELEKTRONIKA MK-42 CALCULATOR

Moscow EKONOMIKA SEL'SKOGO KHOZYAYSTVA in Russian No 11, Nov 83 p 35

[Advertisement for Elektronika MK-42 Calculator]

[Text] The Elektronika MK-42 calculator is in the engineering class. It performs the four arithmetic operations, calculates percentages, allows operations with a constant and calculates inverse values.

The micro-calculator operates with 12-place decimal numbers. It allows changing the sign of a number, accumulation in a memory register with "+" or "-" sign, exchanging contents of operating registers, and mathematical rounding of calculation results with display of two places after the decimal point.

Power requirements are 220V AC.

Dimensions: 212 x 175 x 75 mm.

Weight: 800 g.

Price: 52 rubles.

"Elektronika" TsKRO.
"Reklama" Central Advertising Agency.

8545
CSO: 1863/82

UD-5 GENERAL-PURPOSE DIAGNOSTIC UNIT

Riga NAUKA I TEKHNIKA in Russian No 10, Oct 83 p 4

[Article by Ya. Salenieks]

[Text] How do you check equipment? This task is being handled more or less successfully. For example, an experienced automobile driver can quickly determine what is wrong with an automobile, often without even getting out of the vehicle and while moving. But this is not possible everywhere. More and more often, we have to use meters and computers.

The UD-5 general-purpose diagnostic unit was developed at the School of Automation and Computer Technology in the Riga Polytechnical Institute imeni A. Ya. Pel'she. It differs from its predecessors in functional capabilities, dimensions and element base. The UD-5 is afforded universality by the use of the "Elektronika D3-28" computer. To switch to diagnostics for a different type of equipment, just read in the necessary information from magnetic tape (this takes several minutes on the average).

Information for diagnostics is provided by sensors. In processing it, the unit determines defects and the degree of malfunctioning by the equipment as a whole. The diagnosis is output to an alphanumeric display. The unit also guides the work of the operator by outputting instructions to the display.

Up to 30 sensors can be connected simultaneously to the unit. Diagnostic parameters can be measured under several equipment operating conditions. Total diagnostics time is several minutes. About 25 defects can be detected on the average.

UD-5 operation does not require high skills because the form and content of instructions output can be varied and information on equipment status is expanded to recommendations for eliminating the trouble.

For example, here is how an automobile is checked. The UD-5 is turned on and the required information is read in from magnetic tape; instructions for connecting the sensors are output to the display. For example: Install sensors for temperature, oil pressure, exhaust gas analysis, etc. Then an instruction is output for operating conditions. For example: set the engine crankshaft at 500 rpm. Then, sensor information is read in and analyzed to determine the vehicle's condition. Diagnostic forms: the vehicle needs work; piston wear degree is 0.7; crankshaft bearings wear degree is 0.3; carburetor is not set properly, etc. When required, current values of measured parameters can be output.

To use the UD-5 to check some object in a specific class, information on the given class has to be entered. Preparing this information is a complex matter: A topological model of the object to be checked is built; this model is analyzed and diagnostic parameters are selected; objects are tested and the unit is "taught" to check them. This whole process can be compared to a mechanic acquiring experience. Every experienced mechanic knows well how a given piece of equipment operates, but he acquired this experience mainly by dealing with defective equipment. The more equipment and variety of problems he deals with, the more experienced he becomes. Training the UD-5 is similar. The more adequate the model and the greater the number of objects tested, the more experienced the unit becomes and thus the more objective is the diagnosis.

The UD-5 now has source data for checking axial-plunger pumps and hydraulic motors and is being introduced in the Leningrad "Proletarskiy zavod" PO [Production Association].

UD-5 tests confirmed the effectiveness of the methods developed to check equipment, the diagnostic algorithms, and unit structure. During the tests, the unit had to "compete" against an experienced mechanic. According to the mechanic, the equipment to be checked in the tests had one defect. But the UD-5 found two defects. After checking, the mechanic had to agree with the unit's "opinion."

8545
CSO: 1863/82

UDC 519.68:681.32

PARALLEL CALCULATIONS IN SYSTEM WITH LOCAL INTERACTIONS OF ELEMENTS

Novosibirsk AVTOMETRIYA in Russian No 6, Nov-Dec 83 (manuscript received 3 May 83) pp 88-96

[Article by M. K. Valiyev and A. I. Mishin, Novosibirsk]

[Excerpts] Introduction. An asynchronous calculating system, containing a ring system of processors, each of which is connected to a ring system of memory elements, is suggested in [1, 2]. Several information flows used for access of the operands and that control the signals to the processors, may exist simultaneously in this system, subsequently called a ring calculating system (KVS); one of these flows moves through the processor ring while others move through separate memory rings (ZK). An important means of controlling the operation of the system is the labels written in the control bits of words that permit starting and stopping of the flows to be controlled and also separation of the key flows for processing elements on the associative principle (without direct addressing of the processors and memory elements). All interactions, both information and control, between the elements (processor and memory elements) are carried out as they are ready for interaction. Thus, all types of long communications in the ring calculating system are eliminated and the time of execution of each elementary operation is determined only by the internal characteristics of the elements of the system. Unlike this, the time of execution of an elementary operation also depends on the dimensions of the system in systems that utilize global interactions of processor or memory elements (for example, the total timing or direct memory access) and, accordingly, the number of operating cycles must be multiplied by the weight coefficient, dependent on the dimensions of the system, to determine the actual time for execution of the algorithm. Therefore, known estimates [3] should be multiplied by cn, where c is some constant, rather than by log n, as was done when using the logarithmic weight of operations [3], when estimating the time complexity of the algorithms for processing matrices of order n. Similar refinements should also be made for parallel algorithms [4]. The need to take into account the time of global interactions is also emphasized in [5, 6].

Several examples of matrix algorithms, which are realized rather effectively in a ring calculating system, are presented in [1]. Expansion of ALGOL language by operators for interaction of the processes was used in this case to write the algorithms. Their semantics is similar to the rand mechanism in ADA

language or the interacting sequential processes of Hoare [7]. However, this language is inconvenient for several reasons: 1) the explicit use of operators for interaction severely complicates programming, the understandability of programs and checking of their correctness (there are some inaccuracies even in the rather simple programs from [1] and this is inevitable for programs with more complex interactions), 2) connection of the processors into a ring is used considerably in the programs (the language is machine-oriented in this sense) and 3) interpretation of the language in the ring calculating system is difficult since it is oriented toward a random access memory. MAK (matrix associative coordinate) language, oriented toward description of programs for matrix processing in terms of global (vector or matrix) operators, is suggested in our paper, which permits one to eliminate the use of interaction operations and simplifies programming (the problems related to the correctness of interactions are transferred to the interpretation or compilation phase). In this case the associative principle of control of calculations is realized in the language by introducing masks (generalized selectors) that permit separation of the fragments of matrices to be processed in a special manner. The masks are interpreted in the ring calculating system by the mentioned control labels. The proposed language is similar to APL language, but seems to be conceptually clearer to use, specific and convenient for programming of matrix processing algorithms. It also seems that the concept of the mask may be useful in development of languages operating with richer data structures.

An intermediate language, designed like the language from [1] for programming of individual processors, but which is addressless and expanded with means for working with the memory rings, is used for interpretation of the MAK in the ring calculating system. The operators for interaction of this language, unlike the means of ADA or Hoare language [7], permit very simple hardware realization (specifically, since the language contains no non-determinant structures and problems with guard scheduling are elminated). A system with parallel memory access and bidirectional transmission both for rows and columns has been more generally adapted for total effective realization of the MAK [2]. However, a large part of the language can be effectively realized even in the simplest version of the ring calculating system. Let us also note that some non-numerical algorithms (specifically, sort/merge) are also executed effectively in the ring calculating system.

I. Brief description of the ring calculating system. A version of a ring calculating system in which each processor is connected to several memory rings is used in the paper. A block diagram of the processor element is shown in Figure 1. It functions in the following manner. The control device (UU) reads the next instruction from the program memory (PP) and acording to it sets the element either for processing the data stored in the main memory (OZU) or arithmetic logic unit (ALU) or to transmisison (reception) of data by means of blocks ?i and !i (i = 1, ..., k, where k is the number of adjacent elements) for control of transmission (?) and reception (!) of data. One of the registers (R) in the ALU is allocated for interactions with adjacent elements (data reception and transmission). The operation of blocks ?i and !i is accordingly described by the programs

begin $\alpha_i := 1$; **waituntil** $\beta_i = 1$; $\alpha_i := 0$; **waituntil** $\beta = 0$; **end**
begin waituntil $\alpha_i = 1$; $R := R^{(i)}$; $\beta_i := 1$; **waituntil** $\alpha = 0$; $\beta := 0$; **end**.

Here R and $R^{(i)}$ are the registers for interaction of processors P and $P^{(i)}$, connected by the i-th channel, while the instruction "waituntil Q" means to wait for fulfillment of condition Q. It is assumed that the values of signals α_i and β_i are equal to zero for all values of i at the beginning of operation.

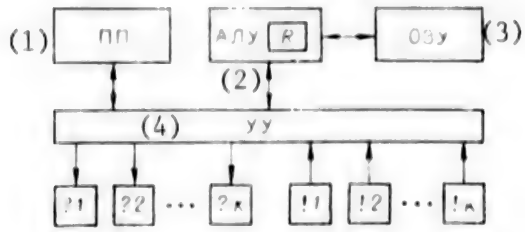


Figure 1

Key:
1. Program memory
2. Arithmetic-logic unit
3. Main memory
4. Control device

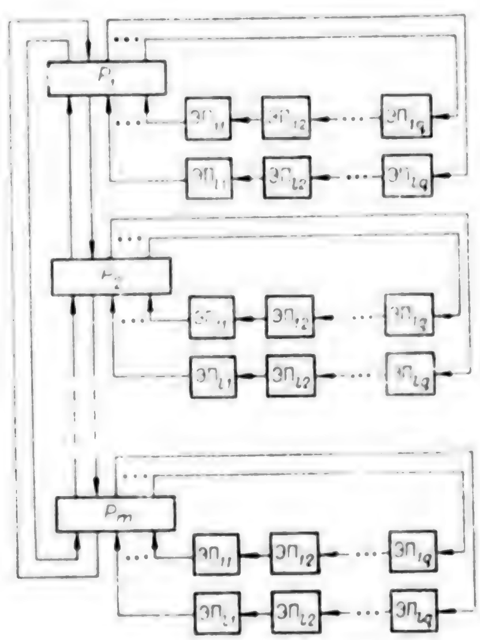


Figure 2

We note that there should be a corresponding transmit (receive) instruction in the program component executed by the processor linked to the processor by the i-th channel for each receive (transmit) instruction over the i-th channel of the program component executed by the processor P.

The memory element of the calculating system differs from the processor by the fact that it contains no control and processing blocks and has a register, reception block and transmission block. The input of each of these blocks is connected to the output of the other; the capability of initial setting of the element to reception by a signal from the processor is also provided.

A block diagram of the system is presented in Figure 2, in which only the information links are shown for simplicity. The ring calculating system contains m processor elements P_1, P_2, ..., P_m, joined into a ring. The processor has l memory rings (ZK) containing a chain of q memory elements EP_{ij}, the output of which is connected to the input through the processor. The different memory rings may have a different length in the general case. Data can be transmitted through the processor ring in two directions and through the memory ring in one direction. Each memory ring is a cyclic asynchronous conveyor for delivery of data (words written in the memory elements and in the transmit status) to the processor. Interaction between the information flows moving through the memory ring of different processors is accomplished by means of an information flow moving through the processor ring. For example a line (matrix) stored in the memory ring of processor P_1 can be removed from all the remaining lines written in the memory ring of other processors in the following manner. Processor P_1 sequentially receives elements a_{1j} from its own memory ring and transmits them to an adjacent processor (for example, the right processor). Processor P_i, $i > 1$, receives element a_{ij} from its own memory ring after reception of element a_{1j} from its left neighbor and transmits $a_{ij} - a_{1j}$ to its own memory ring and element a_{1j} to the adjacent processor on the right (the processor to the left of P_1 transmits only to its own memory ring). Thus, the operation under consideration with sequential time complication n^2 is executed within time 2n.

The ring calculating device is more adaptable for realization of algorithms in which the data are divided into linear arrays (such as rows or columns of matrices), to be processed in their natural order. In this case the memory ring can contain one or several of these arrays. The operation of the system can be represented in the form of cycles in each of which some global operation related to one-time inspection and processing of the contents of one or several memory rings is performed (for example, elimination of a variable in the Gauss algorithm). It is clear that there are usually words within the cycles to be processed by the processor in a different manner. Their control bits are used to identify these words. Writing a "1" to the i-th bit is interpreted as labelling the word with an i-th label. Specifically, a special label Δ is used to label the last word written in the memory ring. We note that it is more convenient to write the control bits of words in some cases in special memory rings. We also note that if this associative method of addressing is insufficient in any cases, direct addressing can always be simulated in the ring calculating system by writing the addresses in the memory elements, but this requires additional memory and reduces the speed.

The operating efficiency of the system depends to a significant degree on the rate of reception of data from the memory ring by the processor. The operating efficiency from the memory rings for matrix algorithms can be estimated roughly by the total waiting time which the processor expends on sequential

reception of all words from the memory ring and transmission of them to the memory ring after processing. Assume that n is the number of words written in a memory ring of length q, δ is the upper bound of the delay time of the memory element and that τ is the lower bound of delay of the processor and condition $2 \le q/n \le \tau/\delta$ is fulfilled. It is then rather easy to understand that the words in the memory ring are distributed during the first operating cycle from the memory ring (the loading step) so that each exchange operation of the processor with the memory ring (transmission or reception) will be performed without a loss of time for waiting (this is provided by the condition $2 \le q/n$ for transmission and by the other part of the inequality for reception). Therefore, tasks that differ rather strongly in dimensionality can be solved even at fixed adjustment of the lengths of the memory rings of the ring calculating system without a loss of operating efficiency with the memory ring (since τ is considerably greater than δ, even if one does not take into account that the delay of the processor can be caused by execution of long program segments without access to the memory ring).

One can also suggest some versions or generalizations of the ring calculating system to increase its efficiency in one or another class of tasks, specifically, for the case of solving systems of differential equations by the decomposition method [2].

II. MAK--matrix associative-coordinate language. 1. Let us present informal description of only some basic part of the language, which however is sufficiently representative and permits one to produce rather clear and compact programs for many practically important matrix algorithms (a program for solution of systems of linear equations by the method of main components will be presented at the end of the section; the corresponding programs in other known languages, including APL and functional languages, are rather cumbersome). The main means of expanding the language will also be mentioned briefly.

There are three types of objects in the version of language under consideration: Boolean values (true and false), masks (finite sets of pairs of natural numbers) and arrays, determined as representations of masks in a set of real numbers. Thus, an array is understood as any fragment of an ordinary two-dimensional array. This expansion of the concept of array is caused by the fact that rather diverse fragments of matrices to be processed in a special manner must be distinguished when processing matrices (for example, an eliminated row or column, diagonal, non-trivial or maximum elements and so on), which can be separated by means of masks that are essentially generalized selectors. In this case a significant part of the program control is connected directly to the data. This connection is very simply realized in a ring calculating system by writing labels in the control bits of words.

We note that masks can be understood the same as sets of cells of an integral two-dimensional lattice $N \times N$ ($N = \{1, 2, \ldots\}$), the first row and first column of which form the coordinate axes with directions from left to right and from top to bottom. The scalars (real numbers) and vectors are considered as special cases of matrices (i.e., of arrays specific in rectangular masks of type $\{1, \ldots, m\} \times \{1, \ldots, n\}$), although the corresponding types of objects can also be introduced.

Two types of variables are used in the language: on masks with descriptions of type S (schablon) and on matrices with descriptions of type M (matrix [1:m, 1:n])

2. The syntax of the language is rather simple and contains standard control aids for structured programming: conditional operators, while-do and until-do cycles, blocks and non-recursive procedures.

Two main types of assignment operators are used:

1) S:=exp, where S is the schablon variable and exp is an expression that assigns the schablons with naturally determined semantics;

2) $M[exp_1]:=exp_2$, where M is the matrix variable and exp_1 and exp_2 are expressions that assign schablons Sh and arrays A, respectively (it is assumed in this case that the current value of Sh of expression exp_1 is contained in the domain of determination of the current value of A of expression exp_2); fulfillment of the conferment consists in the fact that the fragment of matrix M determined by the schablon Sh is replaced by the corresponding fragment of the array A.

Assignments of this type, like "a fixed value is assigned to all elements of the array" or "an array, the domain of definition of which coincides in form to A is assigned to array A with the corresponding shift," are easily expressed by operators of type "2," but they of course can be explicitly introduced. Another suggestive possibility of expanding the language is introduction of types of natural numbers and sets of natural numbers and the related types of cycle operators for and group assignments of the type such as "the value of expression exp (i,j) (or exp (i) is assigned to each element A [i,j] (the i-th row or column) of some set)." These assignments sometimes reflect more directly our understanding of the algorithm and have the more usual form; however, if there types are not limited, some problems arise with realization of them. Moreover, these operators are rather simple to simulate by the operators of the type selected here in practically important cases.

3. Selection of the standard functions to be used is always ambiguous and the list presented in the appendix should be considered mainly as an approximate list.

III. Interpretation of the MAK in the ring calculating system. 1. The MAK can be realized in a ring calculating system both by interpretation and by compilation (based mainly on the same principles). We note that interpretation of separate operators actually reduces to compilation of them in some intermediate programming language for the operation of individual processors. However, a description of the interpretation was selected for the exposition since it is simpler and moreover compilation does not yield as significant an increase of efficiency as usual compared to interpretation for matrix algorithms. We shall limit ourselves here to presentation of the general principles of interpretation and several indicative examples of interpretation of individual operators.

Of course, interpretation depends on the structure of the ring calculating system (the number of processors and memory rings) and the arrangement of data (the elements of matrices to be processed) in the memory. For simplicity let us consider the case when all the matrices to be processed (excluding the vectors) $M_1, M_2, \ldots, M_k$ (including the auxiliary matrices and those not clearly indicated in the program) have identical dimensionality m X n and the system contains m processors, each of which is linked to a (k + 1)-th memory ring of length 2n. The i-th memory ring of the j-th processor (i = 1, ..., k; j = 1, ..., m) is used to write the j-th row of variable M_i (it is assumed in this case that the word length of the registers of the memory elements is sufficient for storage of the values of the matrix elements). The vectors are written in the memory of a dedicated (main) processor. The (k + 1)-th memory ring of the processors (further denoted by ZK_{sh}) is used to write the values of the schablon variables: the l-th bit of the j-th word of the i-th processor contains a "1" if the pair ‹i, j› belongs to schablon S_1. In the other version of realization of the schablons, their values are written directly in the information memory rings, but this is sometimes disadvantageous. We note that both the number of matrices to be processed and of the schablons is low for the actually encountered programs.

The case when the number of processors is less than the number of rows of matrices is mainly similar, although it does have some characteristic features. The diagonal version of arrangement of data in the memory is more complicated and was not considered in detail. The version of storing the matrices by columns is dual to the version under consideration.

It should be noted that some language operators are realized more effectively when the system works by rows and others are realized more effectively when it works by columns (for example, the operation of identification of the schablon by rows is always performed in the first case within linear time, i.e., during a single circulation of data in the memory ring, and in the second case it may require from linear to quadratic time as a function of the type of schablon). A system having a memory with access by rows and columns (this system has more significant advantages in realization of algorithms that frequently use transposition of matrices) would be more suitable in this sense for effective realization of the entire language [2]. However, the transposition operation is not the dominant one for many important matrix algorithms (it is used a small number of times or is used not at all), while other operations, ineffectively realized in the simplest version of the ring calculating system, are used only for the operands contained in the row or column of the matrix and are executed effectively in this case (the corresponding example of the assignment operator y:=col(x) will be considered below).

2. There are two versions of interpretation: 1) each of the processors has its own copy of the program to be executed and interprets it itself and 2) the program to be interpreted and the complete interpreter are contained in only one (the main) processor. Let us consider the second version.

The operation of the system is divided into two steps. At the beginning of each step, the main processor, analyzing the program to be interpreted, generates the next MAK-operator to be executed (assignment or calculation of the

value of the logic condition; in this case all the operators can be regarded as the simplest, i.e., they do not contain complex expressions) and transmits it through the processor ring to all the remaining (slave) processors. Each slave processor contains the program for interpretation of individual MAK-operators and, having received the next operator to be executed, begins to interpret it. The main processor also executes its own part of the operation for interpretation of the operator under consideration, upon completion of which it generates a signal of the end of execution of the operator, transmits this signal to the right processor and converts to waiting for the "end" signal from the left processor. Receipt of this signal by it indicates that execution of the operator is completed and one can convert to the next step. Having completed the execution of the operator, each slave processor converts to waiting for the signal about completion of work from the left processor and, having received this signal, relays it to the right processor and converts to waiting for the operator executed during the next step.

Along with transmission of the signal about completion of execution of the operator, the main processor also transmits a signal about the value of the local condition completed by it to its right neighbor upon execution of the operator for checking the condition, while each slave processor transmits a signal to its own neighbor about the value of the condition with regard to that received from its left neighbor.

3. It is useful to introduce some intermediate language, designed to describe the interaction of individual processors and elements of the memory ring, for formal description of the interpretation of the MAK operators. Special receive (!) and transmit (?) instructions, mainly having the same meaning as interaction instructions in the languages of [1, 7], are introduced to this language. And it is assumed that two elements linked to each other interact with simultaneous observation of the condition when one of the elements executes the transmit instruction and the other executes the receive instruction. These instructions are executed in the system in blocks for reception (!) and transmission (?) of data. The abbreviated notation !?ZK is used for the sequence of instructions !ZK, ?ZK, corresponding to the loop shift of the contents of the memory ring. Some control bit is compared to each schablon x. The value of this bit of register R is denoted by R_x. The neighbors to the left and right of the processor P are denoted by P_l and P_p, respectively.

4. As an example let us present interpretation of the operator G[S]:=0 and of a check of the condition of the non-emptiness of schablon a and of operator y:=col(x), where schablon x determines the subset of some row.

A. Interpretation of operator G[S]:=0. All processors operate independently, alternately counting the words from ZK_{sh} and ZK_G, in which the row of matrix G is written. Depending on the presence of a one in the control bit of the word, counted from ZK_{sh}, a zero is written in ZK_G or the old value is retained. The corresponding program has the form

until $R_x = 1$ **do** !?ЗК$_ш$; **if** $R_s = 1$ **then** !ЗК$_G$; $R := 0$;

?ЗК$_G$ **else** !?ЗК$_G$ **od**

B. A check of the condition $a \neq \emptyset$.

The operation of the system proceeds in two steps. All the processors operate on program Pr_1 in the first step and the i-th processor checks the condition $a_i \neq \emptyset$ (where a_i is intersection of a with the i-th row) for its own ZK_{sh} and the result is recorded in the form of the value of variable u_i. The main processor operates by program Pr_2 in the second step and the remaining processors operate by program Pr_3. Sequential storage of the disjunctive values of all the local conditions is accomplished in this case and the step is completed by reception of the resulting signal by the main processor.

Programs Pr_1, Pr_2 and Pr_3 have the following form:

Пр₁: **until** $R_\Lambda \neq 1$ **do** $!?ЗК_ш$; **if** $R_x = 1$ **then** $u := $ **true else** $u :=$ **false**; **od**.
Пр₂: $R := u$; $?P_n$; $!P_n$
Пр₃: $!P_л$; $R := R \vee u$; $?P_n$

C. Interpretation of operator y:=col(x). This operator is executed in three steps.

In the first step (finding the master), all the processors operate independently by program Pr_1, performing the search in the schablon memory ring for a word with unit value of the control bit corresponding to schablon x. The processor containing this word then operates by program Pr_2 (it becomes the master), while the remaining processors operate by program Pr_3.

In the second step, the left neighbor (absorber) of the master processor, which subsequently executes program Pr_5 (in step 3), is determined.

In the third (main) step, the master processor executes program Pr_4, the absorber executes program Pr_5 and the remaining processors execute program Pr_6. We note that all programs Pr_4, Pr_5 and Pr_6 began with setting their own ZK_{sh} to the standard status when the read word contains the label of the beginning (end) of the row. During this step, the master processor transmits the contents of its own ZK_{sh} to the remaining processors. All the remaining processors, with the exception of the absorber, having received the word from the left neighbor, relays it to the right and, depending on the value of the bit corresponding to schablon x, write a "1" (at $R_x = 1$) in the bit corresponding to schablon y.

Programs Pr_1-Pr_5 have the following form:

Пр₁: **until** $R_x = 1 \vee R_\Lambda = 1$ **do** $!?ЗК_ш$; **od**; **if** $R_x = 1$ **then** Пр₂ **else** Пр₃.
Пр₂: $R :=$ **true**; $?P_л$; $!P_n$; Пр₄
Пр₃: $!P_n$; **if** $R =$ **true then** $R :=$ **false**; $?P_л$; Пр₆ **else** $R :=$ **false**; $?P_л$; Пр₅.
Пр₄: **until** $R_\Lambda = 1$ **do** $!?ЗК_ш$; **od**; **until** $R_\Lambda = 1$ **do** $!?ЗК_ш$; $?P_n$; **od**.
Пр₅: **until** $R_\Lambda = 1$ **do** $!?ЗК_ш$; **od**; **until** $R_\Lambda = 1$ **do** $!ЗК_ш$; $!P_л$; $?P_n$; **if** $R_x =$
$= 1$ **then** $R_y := 1$ **else** $R_y := 0$; $?ЗК_ш$.

Program Pr_6 is distinguished from Pr_5 only by the fact that the instruction $?P_p$ is eliminated.

5. It is easy to see that all the considered operators are executed during linear time (if the lengths of the memory rings satisfy the condition from [1]). One can prove that this is also true for the remaining operators of the Gaussmain program. Since the total number of MAK-operators to be executed have the order n, then the time complexity of this program is estimated as $O(n^2)$. Somewhat more accurate calculations yield the upper bound of $20 n^2 + cn$. The value of constant c, although it depends on the parts of the interpreter, can also of course not be too large. Moreover, if compilation of it is used instead of interpretation of the program, the second term in this estimate approaches zero. Programming the algorithm directly in machine instructions yields a program with time complexity of $5n^2$. There is also the same type of ratio between the time complexity of programs in machine language and MAK language for a number of other algorithms of linear algebra. This indicates that the effectiveness of realizing MAK in a ring calculating system is sufficiently high.

Auxiliary operations, related to finding the master elements, comprise a significant part of the work in solving a system of equations by the method of main elements. It is intuitively clear that a parallel search for the master elements is impossible. The search for each master element occupies on the order of n steps. One can assume in this regard that the estimate of the time complexity of the algorithm presented above cannot be significantly improved even when a large number of processors is used. If this assumption is valid, then it indicates that, despite its own simplicity and apparent boundedness (no more than n processors are used for solution of a system with n unknowns), a ring calculating system is no less effective in realization of some important algorithms than any other system (with arbitrary number of processors). We note for comparison that the cellular automaton of [5] with n^2 processors, which calculate LU-expansion of a matrix of order n during linear time (without regard to the time of input of the initial data), is based on sequential division into diagonal elements and does not operate if at least one of these elements is equal to zero.

BIBILIOGRAPHY

1. Mishin, A. I. and S. G. Sedukhin, "Calculating Systems and Parallel Calculations with Local Interactions," in "Vychislitel'nyye sistemy" [Calculating Systems], No 78, Novosibirsk, Izdatel'stvo IM SO AN SSSR, 1979.

2. Mishin, A. I., "Parallel Calculating Media with Local Interactions of Elements," AVTOMATIKA I TELEMEKHANIKA, No 10, 1982.

3. Acho, A., J. Hopcroft and J. Ullman, "Postroyeniye i analiz vychislitel'nykh algoritmov" [Construction and Analysis of Calculating Algorithms], Moscow, Izdatel'stvo "Mir", 1979.

4. Fadeyeva, F. N. and D. K. Fadeyev, "Parallel Calculations in Linear Algebra," KIBERNETIKA, No 3, 1982.

5. Mead, C. A. and Z. A. Conway, "Introduction to VLSI Systems," Addison-Wesley, 1980.

6. Chazelle, B. and L. Monier, "Optimality in VLSI and VLSI 81."

7. Hoare, C. A. R., "Communicating Sequential Processes," COMMUNICATIONS OF THE ACM, Vol 21, 1978.

6521
CSO: 1863/110

UDC 621.3.049

INDUSTRIAL SYSTEM FOR COMPUTER-AIDED DESIGN OF MULTILAYER PRINTED-CIRCUIT CARD TOPOLOGY

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 (manuscript received 28 Mar 83) pp 28-32

[Article by engineer Vladimir Afanas'yevich Artamonov, Institute of Mathematics, Belorussian SSR Academy of Sciences, Minsk, Candidate of Technical Sciences Aleksandr L'vovich Kuznetsov, Leningrad Institute of Precision Mechanics and Optics, Candidate of Technical Sciences Godar Anatol'yevich Petukhov, Leningrad Institute of Precision Mechanics and Optics, and postgraduate student Svetlana Yur'yevna Yakovleva, Leningrad Institute of Precision Mechanics and Optics]

[Text] The organizational principles, functional capabilities, algorithms and operating characteristics of the computer-aided topology design system (SAPRT) for multilayer printed-circuit cards (MPP), manufactured by the open contact surface method (KP) are described in the given article. The system was developed at the Leningrad Institute of Precision Mechanics and Optics during 1977-1981.

Functional capabilities. The SAPRT MPP automates the main stages of design of multilayer printed-circuit cards: From description of the structure and schematic diagram (PES) to production of the phototemplates of the topology layers used in production of the multilayer printed-circuit card. The hardware base of the SAPRT is YeS computers, beginning with the YeS 1022. Moreover, an ARM-R [automated workstation] with graphic program package GRIF can be used in the correction mode of machine versions of the topology. The following restrictions are placed on the circuit cards being designed:

the maximum overall dimensions of the card are 300 X 350 mm^2 (with discrete grid spacing of 1.25) or 150 X 175 mm^2 (with spacing of 0.625 mm);

the number of external plug connections of the card is not more than 10;

the fitting points (PM) of the components are previously assigned and are located in matrix order (no more than one disturbance of regularity for each of the coordinates is permissible);

the components are either of the same size (the configuration of the fitting point is arbitrary) or are multiples of each other;

the number of PES circuits is not more than 800;

the number of components is not more than 200;

the number of contact areas of a component is not more than 48.

Attachment of some components in fixed positions, prohibition of positions for arrangement of components and announcement of groups of components as "strongly connected" (arrangement of them at a distance not exceeding the given distance) are permissible in design.

External plug connections of circuit cards can have arbitrary configuration: they can be one- and two-row and they can have structural discontinuities in location of contact surfaces. Moreover, the contact surface of a plug connection can be located outside the assemblies of the discrete grid. Arbitrary or fixed access modes of the contact surface for all or some circuits are used to lead the circuits to the contact surface of the plug connection.

The SAPRT database permits design of any structural versions of multilayer printed-circuit cards that satisfy the indicated restrictions. Descriptions of them must be included in the SAPRT libraries for design and use of new series of integrated circuits and new design developments.

The SAPRT operates with three types of libraries: the contact surface library, the locating point library and structural (standard dimensions) library. The latter library contains references to components of the first two libraries. The contact surface library contains a description of the contact surface with which the system operates (their maximum number is 50). The geometric representations of the locating point are stored in the locating point library and the number of types of locating points stored simultaneously in the library is practically unlimited. The recordings of the structural library is a combination of variables that describe the overall dimensions of the assembly, the parameters of the locating point matrix, the configuration of the external plug connections, the areas prohibited for routing and for installation of components and so on.

The SAPRT includes the software that permits introduction and checking of new structural units.

Due to standardization of the language aids for description of the schematic diagrams of assemblies, the SAPRT can be operated in combination with the computer-aided test design system described in [1, 2]. The same debugging aids of the descriptions (syntactical checking and duplication of descriptions) can be used in the design phase conducted autonomously. If the design phase is preceded by the phase of synthesizing the check tests, a finished debugged description can be used.

The capability of automation of the main phases of multilayer printed-circuit card design is provided in the SAPRT: arrangement of the components on the printed-circuit card, routing of circuits, correction of machine versions of topology to improve the technological effectiveness of the article and to eliminate unrealized connections and production of control papertapes for automatic production equipment.

The overall structure and information flows of the SAPRT are shown in the figure. The system uses the principles of data organization described in [2]. The necessary components are rewritten into the so-called "working file of the printed-circuit card" before fulfilling the design. A description of the schematic diagram is also placed here after checking and two-step translation to the internal design language. Since the number of working files is limited only by the total capacity of the external direct-access memory, the SAPRT permits parallel design of a series of assemblies.

The algorithm base of the SAPRT. The algorithms realized in the SAPRT solve design tasks.

Arrangement. The SAPRT can operate in two modes during arrangement of components:

in the mode of arrangement of components of the same dimensions;

in the mode of arrangement of components that are multiple in dimensions.

Assignment of a system of fixed positions for arrangement of components is assumed in both cases. A sequential design algorithm with step permutations is adopted as the basic arrangement algorithm in the system [3]. The position for arrangement is selected by one of the following criteria:

the minimum total ideal length of conductors (estimated by the minimum connecting tree);

minimum maximum length of conductors;

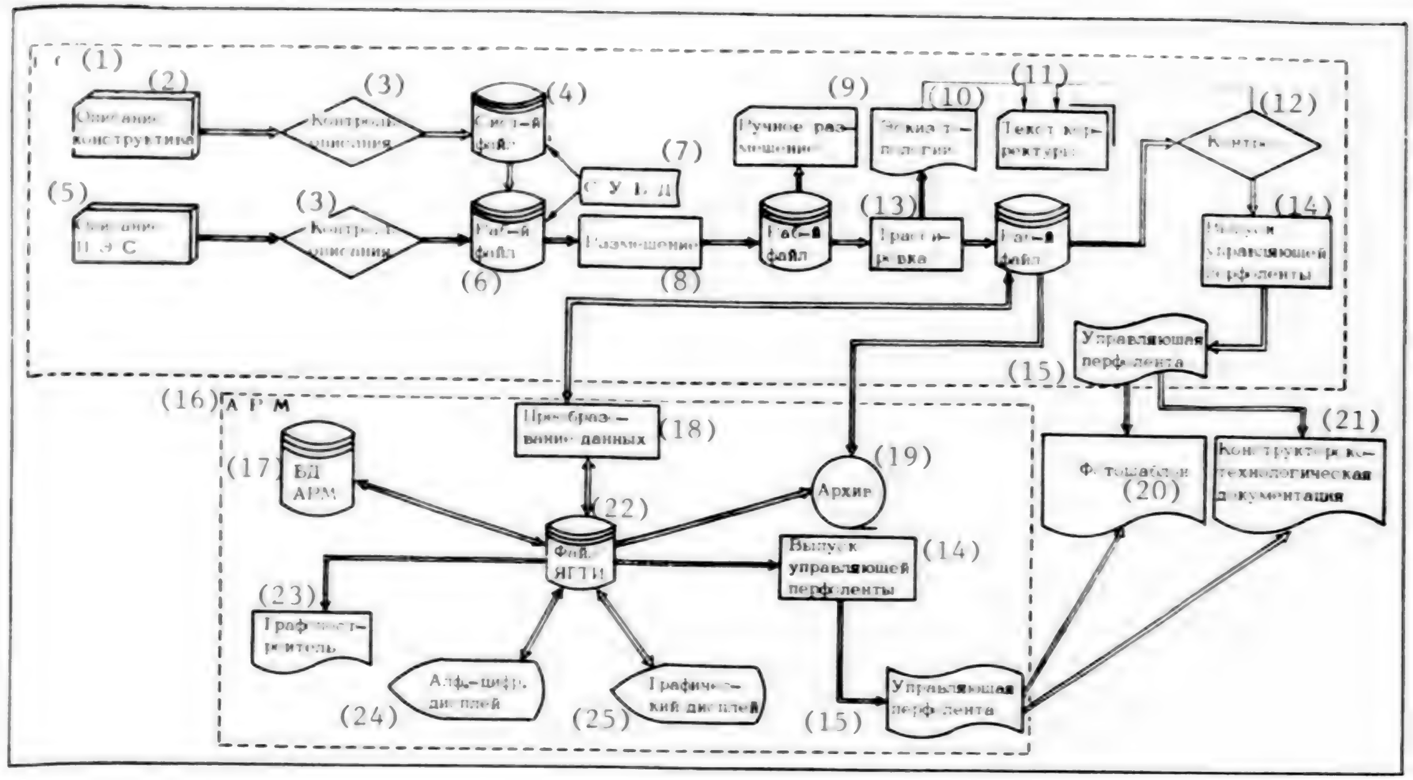
linearization of circuits (preferred orientation along one of the coordinates of the installation space);

the criterion of maximum compactness (opposite to the previous criterion) [4].

The necessary criterion is selected by the user by means of control punch cards. Investigation of the effectiveness of the suggested criteria is presented in [5]. The automated step of arrangement can be omitted if the designer desires. In this case arrangement is carried out manually and is entered into the working file from punch cards.

Routing of connections. The characteristic features of the technique of manufacture of the multilayer printed-circuit card by the open contact surface method is of considerable significance when working out the algorithmic base for routing: a multilayer printed-circuit structure without interlayer junctions requires localization of each circuit in one layer of the printed-circuit assembly.

Two-step routing of each circuit is used in SAPRT. An attempt is made during the first step to connect the contact surface by a small-turn heuristic algorithm. Isolated fragments and the contact surface are commutated in the



Key:

1. Unified series
2. Structural description
3. Checking of description
4. System file
5. Description of schematic diagram
6. Working file
7. Database management system
8. Arrangement
9. Manual arrangement
10. Drawing of topology
11. Correction text
12. Checking
13. Routing
14. Production of control papertape

[Key continued on following page]

[Key continued from preceding page]

15. Control papertape
16. Automated workstation
17. Automated worstation database
18. Data conversion
19. Archive
20. Phototemplate
21. Design-production documentation
22. YaGTI file
23. Graph plotter
24. Alphanumeric display
25. Graphic display

second step by using a wave algorithm (the path coordinate method). A number of production limitations was taken into account in realization of the algorithm: the prohibition of leading the conductor perpendicular to the axis of the contact surface, the prohibition of the route passing under the contact surface realized in the previous layer and arrangement of inactive contact surfaces of components only in the first signal layer. A constant that increases the overall dimensions of the rectangle of minimum area described around the contact surface is used to determine the boundaries of wave propagation.

A two-step routing mode is recommended: an attempt is made in the first step to realize circuits with small value of this constant (5-10 cycles) and to realize circuits with considerably increased value of this constant (50-70 samples) during the second step. This procedure is performed automatically with the initial and increased values of the constant, assigned by the user.

There are different sorting, ranking and stratification modes to change the order of routing in the system.

Sorting is understood as the process of ordering by the increase (decrease) of one of the following characteristics of the circuits:

the number of contact surfaces;

the length of the shortest connecting tree;

the area of the described rectangle;

the number of other circuits, the contact surfaces of which are located inside the described rectangle (the imbedding criterion);

the ratio of the scope of the circuit in one coordinate to the scope of the circuit in another coordinate (the linearity criterion).

The enumerated criteria (with regard to an increase or decrease of their value) provide 10 sorting versions.

Ranking is establishment of the preferred orientation of the circuit along one of the circuit card coordinates. This permits one to control the preferred direction of routing in each layer, which as shown by practice, increases the number of drawn circuits.

The circuits are stratified on the basis of analyzing the mutual arrangement of the contact surfaces of the circuits in the assembly space.

The priority mode of circuits connected to the external plug connection is also provided in the program routing module.

Using the combination of sorting, stratification, ranking and routing modes, the user can achieve more than 100 different operating modes of the routing module. The modes can also be replaced in design of each layer. Having made a number of trial versions of routing, the user can select the best from the viewpoint of realizability of the circuits and subsequent manual correction.

Correction of machine versions. This step is necessary in any industrial SAPRT due to the lack of capability of complete realization of the entire set of circuits under conditions of restriction of the number of layers for a card of arbitrary complexity. The machine version of the topology can be corrected in the SAPRT in two modes, depending on the configuration of hardware use.

The batch correction mode: in this case a special data language [6], which permits one to change the configurations of the routes of individual conductors, to remove and introduce new routes and to transfer the contact surfaces of the microcircuits and of the external plug connections from layer to layer, is used in this case to make the correction. The user, having available a drawing of the layer of the circuit card to be changed, describes all the required changes in the correction language. When the correction batch is submitted, the input data is checked syntactically and semantically. A modified drawing of the topology is printed out after the correction is made.

Because of the relative inconvenience of correction in the described mode, the more efficient and convenient interactive mode of correction using the APM-P complex is provided in the SAPRT. To provide this mode, the system includes two program modules that perform the role of pre- or post processors. They provide a translation of the description of layer topology from the language used in the SAPRT to the graphic and textual data language [7] and vice versa. The user is able to correct the topology in the graphic interaction mode after translation of the information arrays and after output of the text in the indicated language to papertape. A graphic monitor using a display or correction of the text in the graphic and textual data language is possible by using the GRIF graphic program package under control of the DOS SM [SM disk operating system]. After completion of the correction session in the indicated mode, the post processor carries out reverse translation from the graphic and textual data language to the internal language of the SAPRT for entry into the YeS computer. Data about the effectiveness of correction in the graphic interaction mode is presented in [5].

Automatic checking of topology. Regardless of the correction mode, automatic checking of topology is provided in the SAPRT. The conformity of the topology to the description of the schematic diagram (completeness of realization and absence of short circuits and breaks) and adherence to production restrictions (prohibitions for routing, delivery of the conductor to the contact surface, passage of the conductor under the contact surface of the previous layer) are

checked. During the check, diagnostic messages are printed about the errors made by the designer during manual correction. Purely machine versions of the topology are also checked after changes and additions have been made to the routing module.

Output of control papertapes. The set of papertapes, which is the result of the work of the SAPRT, contains control data for manufacture of layer templates, for card blank punchers and for finished assembly checking devices. To obtain a complete set of papertapes, the SAPRT is integrated with the automated papertape output system (ASVP). The ASVP permits connection of several types of coordinate graphs and graph and photoplotters (M-2000, KPA-1200 and EMMA). The ASVP can be used independently in semiautomatic design or correction.

Operating characteristics. The main operating problem is complete elimination of errors and violations of the restrictions of the system at the input of the program modules, since a committed error leads to significant losses of machine and manual time. The most frequently encountered error is structural incompatibility of the schematic diagram and of the selected standard dimension (non-conformity of the number of component leads and locating points, the impossibility of arranging all components and so on).

Operation of the SAPRT is complicated sharply if the complexity of the schematic diagram is increased. The requirements on selection of the optimum sequence of circuit routing increase even with a proportional increase of the assembly space (for example, with a change to a smaller step of the discrete grid). An unsuccessful sequence may lead to a low percentage of circuit realization. In this case, manual correction is ineffective due to the large volumes of correcting operators and complex visual analysis. Unfortunately, the optimum routing mode can be established only experimentally upon inspection of several versions.

Experience of industrial operation. In 1980-1981, 240 multilayer printed-circuit cards, manufactured by the open contact surface method, were designed by using the SAPRT. The number of integrated circuits on the cards fluctuated from 48 to 104, the number of circuits fluctuated from 128 to 380 and the number of pair connections fluctuated from 234 to 825. The structural characteristics of the cards are: overall dimensions--125 $\pm$ 10 mm and 180 $\pm$ 15 mm, number of external plug connections from 2 to 4 and number of external contact surfaces--approximately 150.

Data that indicate the effectiveness of using the described system in design of most assemblies of the class under consideration are presented in the table. The experience of computer-aided design confirms that the main index of the complexity of schematic diagrams is the number of pair connections (the number of commutated contact surfaces); therefore, the cards to be designed are classified according to this criterion. The averaged design indices for each group of cards are presented in the table. The data of the table indicates a higher utilization factor in design of assemblies of low and medium complexity. The use of the SAPRT becomes unfeasible for complex cards in some cases due to the great laboriousness of manual correction. Thus, the process

Data on Operating Efficiency of SAPRT

(1) Показатели	Сложность ПЭС (число соединений) (2)					
	(3) до 300	до 400	до 450	до 500	до 600	(4) свыше 600
(5) Число спроектированных плат	85	63	42	27	15	8
Время подготовки и контроля исходных данных (человеко-час) (6)	4,0	4,5	6,0	8,0	10,5	12,5
Процент реализованных соединений (7)	98,3	94,7	89,0	86,0	83,7	81,5
Время расчета одного режима трассировки (час) (8)	3,4	4,2	4,6	5,2	6,8	7,0
Трудоемкость ручной коррекции (человеко-час) (9)	3,5	4,8	5,9	8,6	15,0	28,5
Объем корректировочных массивов (перфокарт) (10)	55	95	150	230	310	450
Время контроля и корректировки (мин) (11)	13	14	20	28	32	36
Число плат, переведенных на ручное проектирование (12)	—	—	—	1	1	4

Key:

1. Indices
2. Complexity of schematic diagram (number of connections)
3. Up to
4. More than
5. Number of designed circuit cards
6. Time for preparation and checking of input data (man-hours)
7. Percentage of realized connections
8. Time for calculation of one routing mode (hours)
9. Laboriousness of manual correction (man-hours)
10. Volume of correction arrays (punch cards)
11. Time for checking and correction (minutes)
12. Number of cards converted to manual design

of design using the SAPRT was not carried to the end for six cards (see table). All seven layers of these cards were designed manually. The control papertape for these assemblies was produced by using the ASVP in the autonomous mode.

Data on the machine time of routing for the YeS 1022 computer, presented in the table, are related to one set of modes, although 2-3 versions of modes had to be used for approximately 30 percent of the cards to obtain an acceptable version of the topology.

Prospects for development of SAPRT. Being a system designed on the modular principle, the SAPRT permits expansion of its functional capabilities. Experimental operation of the routing modules for two-sided printed-circuit cards is under way and modules for checking and correcting them have been developed.

The algorithms and programs for synthesis of multilayer printed-circuit structures with interlayer junctions have been developed. The database to provide the capability of designing assemblies with different sized components, arranged in unfixed positions, and for the use of an unlimited number of different types of contact surfaces is being completed.

The basic direction for development of SAPRT is now creation of algorithms and design models directed toward reduction of the number of corrections, not made in the automatic mode, and that also provide solution of the problems of arrangement and routing of considerably larger dimensions.

BIBLIOGRAPHY

1. Shipilov, P. A. and N. A. Yanshina, "Preparations of Descriptions of Logic Circuits for Automation of Hard-Copy Design System," in "Primeneniye vychislitel'nykh mashin v proyektirovanii i proizvodstve pechatnogo montazha" [The Use of Computers in Design and Production of Printed-Circuit Assemblies], Leningrad, LDNTP, 1975.

2. Nemolochnov, O. F., A. Ye. Usvyatskiy, V. F. Zvyagin and V. N. Golynichev, "An Industrial Computer-Aided Text Design System," UPRAVLYAYUSHCHIYE SISTEMY I MASHINY, No 5, 1981.

3. Selyutin, V. A., "Mashinnoye konstruirovaniye elektronnykh ustroystv" [Computer-Aided Design of Electronic Devices], Moscow, Izdatel'stvo "Sovetskoye radio", 1977.

4. Petukhov, G. A., S. A. Arustamov, A. L. Kuznetsov and S. Yu. Yakovleva, "Experience of Operating Multilayered Printed-Circuit Card Computer-Aided Design System," in "Mashinnyye metody proyektirovaniya EVA" [Machine Methods of Computer Equipment Design], Leningrad, LDNTP, 1979.

5. Petukhov, G. A., S. A. Arustamov, A. L. Kuznetsov and K. K. Yengibaryan, "Experience of Digital Equipment Topology Design Using YeS Computers and Automated Workstations," PROMYSHLENNOST' ARMENII, No 3, 1982.

6. Arustamov, S. A. and A. L. Kuznetsov, "Principles of Organization of Automated Checking and Correction of Topology," in "Mashinnyye metody proyektirovaniya EVA", Leningrad, LDNTP, 1979.

7. Vermishev, Yu. Kh., Yu. M. Yelshin, V. F. Bibikov and Z. I. Lomakina, "The Structure of Graphic and Textual Data in Computer-Aided Design Systems], OBMEN OPYTOM V RADIOPROMYSHLENNOSTI, No 2, 1977.

6521
CSO: 1863/104

UDC 681.5.621:681.3

SIMULATION SUBSYSTEM IN COMPUTER-AIDED DESIGN SYSTEM FOR NAVIGATION INSTRUMENTS

Kiev MEKHANIZATSIYA I AVTOMATIZATSIYA UPRAVLENIYA (NAUCHNO-PROIZVODSTVENNYY SBORNIK) in Russian No 4, Oct-Dec 83 (manuscript received 3 Mar 83) pp 41-44

[Article by Doctor of Technical Sciences R. I. Sol'nitsev, engineer A. S. Presnyak, engineer I. M. Terterova and engineer I. V. Kovtun]

[Excerpts] An SAPR [computer-aided design system] for navigation instruments (NP), designed for automation of design work in development of precision electromechanical devices that are complex control systems, is being developed at LETI imeni V. I. Ul'yanov [Leningrad Electrotechnical Institute imeni V. I. Ul'yanov]. The computer-aided design system for navigation instruments is regarded as a tool [1] which permits the designer to automate his work at all steps--from coordination of the technical assignment to publication of the planning documentation and programs for machine tools with ChPU [numerical program control].

The software of the computer-aided design system for navigation instruments is constructed on the basis of the unified integrated system SPIN [2], which offers the programmer basic aids for development of flexible problem-oriented languages for different groups of users. The simulation subsystem created within the framework of SPIN and that permits one to achieve time processes in mathematical models (MM) of the object under investigation, is considered below. The mathematical models are assigned by the user in problem-oriented language TEMP in analytical form. The simulation subsystem is linked with respect to information to the computer-aided design subsystem for the mathematical model in analytical form for the mechanical part of devices of a specific class, which permits the use of previously designed mathematical models, making the necessary changes in them and expansion of them. The proposed subsystem is oriented toward fast methods of simulation of complex control systems described by differential and difference equations.

The main characteristics of the existing simulation systems can be considered the presence of a convenient input language that permits one to describe models of a specific class, the capabilities of representing the mathematical models in different forms and the presence of effective computer procedures that realize the process of simulation and means of output and processing of the results of simulation. Most known universal simulation systems (for example, NEDIS,

DYNAMO, CSMP, GPSS and CSSL III) essentially use expansion of algorithmic programming languages (most frequently FORTRAN) and are oriented toward users who have a good knowledge of these languages. A preprocessor that translates the simulation program to the basic algorithmic language is usually employed in these systems during translation of the programs. This rather cumbersome mode places specific restrictions on the forms of representation of the mathematical model and increases the simulation expenditures.

The purpose of the described investigations is to bring the simulation language closer to traditional mathematical symbolism. The main restrictions of TEMP language are related to the characteristics of existing peripheral input-output devices.

Special attention is devoted to procedures of numerical integration used in the simulation subsystem. Besides the standard programs, procedures are oriented toward solution of rigid systems, specifically, the GEAR procedure modified by Hindmarsh [3], are used.

Investigations are now being conducted on creation of a program that permits the numerical integration modules to be adjusted to a specific mathematical model. In this case the structural adaptation of the numerical integration algorithm can be included not only in selection of the method of integration and of its order for the entire system, but also in the use of various difference schemes for individual equations and groups of them contained in the system. Sequential integration of equations, which assumes preliminary sorting of them in the system, permits a significant increase of the efficiency of the computing procedures.

For modeling discrete continuous systems questions arise of matching the discrete cycle with the calling of the integration procedure and with outputting the results. An entity may have several discrete parts with various discrete cycles. This problem is being solved by means of a unit that synchronizes the numerical integration of the analog part, by means of competitions for the digital part and output of the results. Output of the simulation results is accomplished by using the VYVODIT' operator. The results can be derived in the form of tables and in the form of graphs and the combined output of tables and graphs is possible. The scale of output of graphs is either controlled by the user or is calculated automatically. Five forms of output of results are realized in TEMP language.

BIBLIOGRAPHY

1. Sol'nitsev, R. I., I. V. Kovtun and A. S. Presnyak, "Derivation of the Equations of Motion of Complex Electromechanical Systems in Adaptive Form on a Digital Computer," IZVESTIYA LETI, No 287, 1981.

2. Sol'nitsev, R. I., A. V. Kovalev, I. V. Kovtun and A. S. Presnyak, "SPIN--An Instrument System for Software Design of a Computer-Aided Design System for Electromechanical Instruments," in "Avtomatizatsiya proyektirovaniya i konstruirovaniya: Trudy II Vsesoyuznogo soveshcheniya" [Automation of Planning and Design: Proceedings of the Second All-Union Conference], Leningrad, 1983.

3. Hindmarsh, A. C., "GEAR: Ordinary Differential Equations System Solver," Lawrence Livermore Laboratory, Report UCID-30001, December 1974.

6521
CSO: 1863/108

PROGRESS IN ACADEMY OF SCIENCES ON SCIENTIFIC RESEARCH RELATED TO DEVELOPMENT OF THE THEORY OF INDUSTRIAL ROBOTS AND THEIR APPLICATION

Vilnius TRUDY AKADEMII NAUK LITOVSKOY SSR, SERIYA B: KHIMIYA, TEKHNIKA, FIZICHESKAYA GEOGRAFIYA in Russian No 3(136), 1983 pp 127-129

[Article by V. Petrauskas and S. Skebiene]

[Text] To expand scientific research in developing industrial robots within the Academy of Sciences and introduce coordination of research underway in this area in the republic, the Academy of Sciences Presidium adopted the following resolutions: (No 27) on 1 February 1982, "On Measures for Fastest Introduction of Industrial Robots in the Republic Economy for the Period 1981-1985" and (No 186) on 31 May 1982, "On Areas of Application of Advanced Automatic Manipulators with Program Contr l."

To coordinate the republic's current scientific research on developing the theory of robots and their application, the Commission on Research in Industrial Robots was established (resolution No 27) under the LiSSR Academy of Sciences Presidium (chairman is Academician Y. Motskus (IMK) [Institute of Mathematics and Cybernetics], deputy chairman is D. Zanyavichyus (IFP) [Institute of Semiconductor Physics], candidate of engineering sciences, and the secretary is A. Bashkis (IFP) [Institute of Semiconductor Physics]).

The Academy of Sciences Presidium approved the proposals submitted by the Commission on development, deepening and coordination of research in this area in the republic, and the topics of research underway in the Academy of Sciences institutes and republic VUZ's (19 positions), the results of which can be used to develop automatic manipulators with program control.

Considering the established demographic situation, full automation of production should be considered a basic path for further development of industrial production.

An inseparable part of full automation of production, the role of which in future will be continually increasing, is the application of automatic manipulators with program control.

Solving the problem of development and production of general-purpose robots and automatic manipulators or their modules in the republic requires more

research which could best be performed by "Litstankoproyekt," the Lithuanian Scientific Production Association for Design of Machine tool Plants.

Practice shows that in the republic in the first place, robots for transfer (at the Panevezhis "Ekranas" plant) and checkout (at the Shyaulyay Television Plant imeni the 40th Anniversary of Soviet Lithuania) should be and are being introduced; therefore, it is advisable to consider these plants as prototypes in the area of introducing robots. In planning their theoretical research, republic scientists must also consider that robots designed for transfer and checkout in industry will also be dominant in the near future.

To introduce robots and manipulators into industry where they are really needed, it is necessary to strengthen departments for automation of production in major plants 1.5- to 2-fold, entrust them with drafting plans for full automation of production and define the optimal role of robots and manipulators in these efforts. In automating production processes and equipping them with robots, we must also consider that using industrial robots not only reduces manpower, but also substantially increases production flexibility and significantly reduces metal consumption compared to the transfer of performance of the same work to automatic lines. It may also be useful to equip outdated processes with robots when a product change is imminent.

Automation departments must pay special attention to development of the tool base since otherwise the application of robots will not be efficient. Specifications on development of new automatic lines and equipment must be coordinated with the departments for automation of production.

Equipping with robots must be performed consistently, according to the long-range plan for full automation, and not by first acquiring robots and then thinking about where they will be used.

For proper robot operation, 10-20 maintenance technicians are needed annually at the Panevezio "Ekranas" plant alone. They could be trained, for example, at the Panevezio Polytekhnikum. When other republic plants are equipped with robots in future, the need for maintenance technicians will significantly increase; therefore, the Ministry of Higher and Secondary Specialized Education in the republic together with the Gosplan should draft long-range plans for training these maintenance technicians. Plans should also be drafted for training engineers and skilled workers to work with robots, but right now the primary shortage is in maintenance technicians.

In the near future, republic industries should begin producing the individual elements needed for the industrial robots under development in the country.

The "Precision Vibration Mechanics" scientific production association (directing organization of the KPI [Kaunas Polytechnical Institute imeni Antanas Snechkus]) is capable of developing and producing micro manipulators designed for especially precise operations.

Republic scientists should develop unique structural elements for robots: transducers, precision mechanisms and adapters.

Three problems are being encountered in introducing industrial robots in the republic: There are no reliable standard transducers, standard modules for the mechanical part and electromechanical transmissions suitable for robots.

Both now and in future, robot reliability will be a major problem since one erroneous action by a robot may cause a major accident. This problem should be solved both through raising reliability of elements, assemblies and modules for robots and by developing reliable robots from unreliable elements.

Since the operations performed by robots will become more complicated, the role of control system hardware and software will be enhanced.

The theoretical aspects of software for processes using robots in the republic could be handled by the IMK [Institute of Mathematics and Cybernetics], while the IFP [Institute of Semiconductor Physics] could handle the hardware.

Efficient development of software is essentially impossible without a well specialized language and appropriate translators. Robots for transfer and checkout are the most critical in the republic; therefore, development of specialized languages and translators for robots in this class must be included in drafting long-range plans for the scientific effort of the republic Academy of Sciences and Ministry of Higher and Secondary Specialized Education.

The institutes of the Academy of Sciences (IFP [Institute of Semiconductor Physics], IMK [Institute of Mathematics and Cybernetics], IFTPE [Institute of Engineering Physics Problems in Power Engineering]) and VUZ's in the republic (VGU [Vilnius State University imeni Vintsas Kapsukas], KPI [Kaunas Polytechnical Institute imeni Antanas Snechkus]) should pay special attention to scientific topics needed to develop the theory of automatic manipulators with program control and application of them in practice.

On 12 July 1982, the Academy of Sciences Presidium adopted resolution No 239, which added the topic of research on industrial manipulators to the plans for basic research in the IFP [Institute of Semiconductor Physics] and Academy of Sciences for 1982 and 1983.

8545
CSO: 1863/54

UDC 65.012.122:658.012.011.56

IMPROVING THE USE OF OPTIMIZATION CALCULATIONS IN AUTOMATED CONTROL SYSTEMS OF UKRAINIAN SSR

Kiev MEKHANIZATSIYA I AVTOMATIZATSIYA UPRAVLENIYA (NAUCHNO-PROIZVODSTVENNYY SBORNIK) in Russian No 4, Oct-Dec 83 (manuscript received 3 Mar 83) pp 1-5

[Article by Academician of Ukrainian SSR Academy of Sciences V. S. Mikhalevich, Doctor of Economic Sciences M. T. Matveyev and Candidate of Technical Sciences V. V. Samsonov]

[Text] The problems of using economic mathematical methods in planning and management of facilities of the national economy have been especially manifested recently in the field of increasing the intensity and effectiveness of real application of them. Study of these problems was entrusted to a scientific and technical committee created by the Interdepartmental Council on Problems of Improvement of Management in the National Economy of the Ukrainian SSR, with regard to the experience and recommendations of the committee attached to the USSR GKNT [State Committee for Science and Technology] [1]. The results of generalization of the materials of investigating optimization problems are presented below.

The committee considered approximately 400 optimization problems being operated and developed in the republic's OASU [sector automated management system] and ASUP [automated enterprise management system]. Approximately 37 percent of this volume consisted of problems of annual planning and approximately 2 percent consisted of problems of 5-year planning.

The comparable analysis between ASU and in separate systems was made difficult due to the ambiguity of the concept "problem" and the absence of recommendations of how many and which problems should be in the system. Therefore, the specific weight of the number of optimization problems in the total number of a specific ASU was used as an arbitrary evaluator. This estimate for some ASU reached 5-7 percent during the 10th Five-Year Plan during implementation of the integrated-specific program for creation of the RAS [Regional Automated System] of the Ukrainian SSR and showed that optimization calculations did not achieve proper development in the ASU, while they were generally absent in 40 percent of the investigated OASU. The volume of designs that were not carried through to introduction in a number of ASU reaches 40-60 percent and not a single design is being used in some ASU.

One of the causes of this situation is the isolated nature of optimization problems from other problems of ASU. Most of them are used for one-time calculations, they do not take into account the constantly appearing changes and they are not inscribed in the generally accepted planning and management scheme. This is explained by the absence of systematic working through of problems for creation and development of specific ASU, among which implementation of the principle of new problems [2] would be carried through to practical measures.

Deficiencies in development of economic mathematical models is another reason. Analysis of the models showed that they are not adequate to the activity in many cases because of the difficulties of formal description of many limiting conditions of the real process. At the same time, careful consideration of all the limiting conditions considerably restricts the range of permissible solutions and frequently brings the optimum version of the solution closer to the version which can be calculated manually.

In those cases when the developers manage to solve the problem of the feasibility and inflexibility of taking into account the corresponding limiting conditions, the "viability" of these problems is enhanced considerably. They include calculation of the optimum operational formulas for mixed feeds and protein-vitamin supplements, which is used in the ASU of Minzag USSR [Ukrainian SSR Ministry of Procurement] in the industrial mode to make up formulas for the mixed feed enterprises of the sector.

The inadequacy of the models in some cases is explained by the incapability of online correction of the changing conditions of the course of the processes to be analyzed. General systems aids developed at a number of OASU permit selection of the model parameters in interactive mode from the created sector database, achieving adequacy of it, make it possible to organize an initial file for the software package, to accomplish an interface with it and to carry out optimization calculation.

The inadequacy of the models is also explained by the lack of substantiation of selection of the criteria and by the contradictory nature by that...exists, which exist in practice. Unsuccessful attempts are frequently made to replace some criteria by another, which is complex conditional-economic in nature. All this makes difficult and sometimes makes impossible practical use of these calculations.

Attempts to represent the capabilities of enterprises in sector models at the level of aggregate indices lead to a loss of specifics and to inadequacy of the models. Compilation of expanded models, when subordinate enterprises are represented at the level of detailed indices, leads to their immensity and to the incompetency of specialists to make decisions in these terms. The resolution to this situation may be in creating a complex of interconnected multilevel models that reflect the hierarchy of the management system and the corresponding degree of aggregation of indices.

Difficulties in use of tasks of problems, in the results of solutions of which a number of organizations are interested, have been made clear. Thus the problem of calculating efficient routes for shipments of sugar beets from

sugar beet-growing farms to sugar plants and to sugar beet reception terminals is being solved in the OASU of Goskomsel'khoztekhnika [not further identified] of the Ukrainian SSR for Obltranssel'khoztekhnika [not further identified], whereas the sugar beet-growing farms are being assigned to the receptor terminals by Minpishcheprom [Ministry of the Food Industry] of the Ukrainian SSR. The problem of optimum attachment of coal enterprises to consumers of coking coal is being solved simultaneously at Minugleprom USSR [Ukrainian SSR Ministry of the Coal Industry], Minchermet USSR [Ukrainian SSR Ministry of Ferrous Metallurgy] and Ukrglavugol' [not further identified] of the Ukrainian SSR Glavsnab with regard to their own interests and of the suggested requirements of related departments. Solution of these problems requires the development of an hierarchical complex of models within the framework of the Ukrainian SSR RAS with organizational tie-in of it to the directive organization responsible for the corresponding national economic task.

Complexes of optimum functional models of the corresponding economic objects rather than individual models must be developed at the modern stage. Such a complex should offer the capability not only of obtaining the optimum version of the plan under fixed production conditions but also should find the possibilities of changing these conditions to achieve a directively assigned version, which is not permissible with the existing organization of production. The complex should permit one to find the coordinated plans of all sections of an economic object with different functional criteria of each section and of the object as a whole, should take into account the requirements of phase planning, should control the process of implementation of the plans, should reflect the organizational structure of the object and should thus offer individual workers the capability of communicating with it and should take into account their interests during decision-making and implementation of decisions.

The developers of the OASU of the Ukrainian SSR Minugleprom, which provides for development of integrated databases, have converted to a new methodology of sequential optimization, coordination and making planning and control decisions on the basis of standard TISPLAN aids. The system reproduces an analog of the organizational structure of the object, preserves the hierarchical relationships manifested during management, simulates the planning, search and output of versions of solutions to the person making the decision (LPR) and simulates the interaction of the LPR with the computer, by using a complex of interconnected economic and mathematical models [3].

More than 80 percent is related to the class of linear programming tasks, although the essence of the processes to be simulated frequently requires the use of more complex methods of non-linear (6.4 percent), dynamic (approximately 5 percent) and stochastic programming and so on. For linear programming tasks there is extensive experience of industrial use only for small dimensionalities of the initial conditions matrices (100 x 100) and experience of one-time solution of average size with a small matrix free factor.

Methods of solving linear and non-linear programming tasks of large dimensionality, direct methods of stochastic programming, methods of

large-dimension discrete programming, methods of multicriterial optimization based on ideas of mutual tie-in of heuristic procedures that utilize unformalized knowledge of specialists, to strict mathematical procedures of finding solutions and so on are being developed at the Institute of Cybernetics, Ukrainian SSR Academy of Sciences. Many of them have been brought to program realization in the form of applications program packages (PPP) for solution of discrete programming (DISPRO) tasks, for solving uneven optimization tasks (PIONER), for solving placement and design tasks (VEKTOR) and so on.

However, as shown by analysis, only approximately 30 percent of the tasks have been developed by using Soviet or foreign PPP. This is explained by the absence of the required service maintenance of applications program packages that provide data input-output and analysis of the incompatibility of systems of restrictions and solutions found; the absence of means for "joining" to database management systems and means that provide interactive problem-solving procedures; the absence of the required maintenance documentation and the necessary consultations for adaptation of the applications program packages and also different types of technical equipping of computer centers. In view of this, the number of problems (approximately 1.2 percent) realized by firmware, which include interactive procedures and those that provide working with data banks and that use other general systems aids, is insignificant.

The insignificance of using standard design solutions increases the laboriousness of working out the problems: it is no more than one man-year for 6.3 percent, 2-3 man-years for 41 percent, 5-7 man-years for 19 percent and 15-30 man-years for 21 percent. The volume of programs does not exceed 4,000 operators for 72 percent of the problems.

Another cause of the high laboriousness of working out problems is the shortage of highly skilled specialists and their dispersion through different organizations. The productivity of development and debugging of programs indicates this: it does not exceed 10 operators per day for 58 percent of the problems, 10-50 operators per day for 39 percent and only 50-80 operators per day for 3 percent. The latter programs are developed on the basis of automation of this process by using the corresponding general systems aids.

Many organizations (five or more) are developing optimization problems simultaneously for many ASU without sufficient scientific methodical coordination, while the developers of ASU, who have insignificant experience in working with them are involved with introduction.

The delaying factor in intensification of the process of development and introduction of optimization problems is the information support for solving them, which is indicated by the very high laboriousness of preparation of initial data: approximately 18 man-days is required for 72 percent of the problems, 140 man-days is required for 25 percent and more than 1,000 man-days is required for 3 percent. Most problems are not included in the unified computation complexes of ASU in which they would be provided with the required service in preparation of the input data, in analysis of intermediate and final results and so on. The number of optimization problems being used in these complexes is a little more than 1 percent.

Introduction of optimization problems requires the use of new data absent in the existing regular document flow. The developers link solution of this problem in some cases to the corresponding organizational and informational restructuring of the object without comparing the expenditures for this to expenditures for development of the necessary models and the expected savings due to introduction of them.

The different times of arrival of input data is observed, which is explained by weak interaction of different services and departments when working out the plan, which is limited by coordination of the resulting indicators of the planning sections rather than by coordination of the content of specific organizational and technical measures.

The low accuracy of input data leads to minimum expenditures for development of complex models and precise mathematical methods of problem-solving. The absence of the necessary normative data leads to replacement of it by expert analyses and by statistical data that does not take into account the changes occurring in the organization of production and that sometimes do not correspond to their capabilities.

Solution of the named problems requires the development of integrated databases from the developers of ASU as the bases for solution of optimization problems. Integrated databases are now being created in only several sectors in the republic and less than 6 percent of the optimization problems are solved on the basis of unified databases for the ASU. The laboriousness of solving them does not exceed 13 man-days.

The difficulties in the area of hardware for solution of optimization problems include different types of technical bases of individual ASU, which does not permit sufficiently effective distribution of the positive experience of their use, the technical characteristics of many computer complexes do not meet problem-solving requirements (speed, memory capacity, required peripheral devices and so on) and unjustified orientation in solution of problems only in computers of the YeS series rather than on complexes of YeS computers and minicomputers. The delaying factors in creation of these complexes are the absence of software for organization of intermachine data exchange between mini- and large computers, effective methods and applications program packages for solution of large-dimension optimization problems and methods and software for interrelated solution of complexes of planning and operational management problems.

The ideology of systems optimization, outlined by V. M. Glushkov [2], is being implemented at the Institute of Cybernetics, Ukrainian SSR Academy of Sciences, for sector planning problems. The basis of the new man-machine technology for compilation and optimization of plans are the principles of sequential aggregation of norms that link all planning levels, design of dynamic models on a static basis, multicriterial optimization of plans and interlevel coordination of planning decisions as a sequence of decisions for changing a plan, coordinated at all levels of the planning hierarchy. Implementation of this ideology will make it possible to eliminate many of the named difficulties and to increase the effectiveness of introduction of optimization problems.

BIBLIOGRAPHY

1. Kantorovich, L. V., N. I. Cheshenko, Yu. M. Zorin and G. I. Shepelev, "The Use of Optimization Calcualtions in Automated National Economy Sector Management Systems," EKONOMIKA I MATEMATICHESKIYE METODY, Vol 14, No 5, 1978.

2. Glushkov, V. M., "Osnovy bezbumazhnoy informatiki" [The Fundamentals of Paperless Informatics], Moscow, Izdatel'stvo "Nauka", 1982.

3. "Tezisy dokladov respublikanskoy konferentsii 'Problemy sozdaniya i perspektivy razvitiya ASU v ugol'noy promyshlennosti', Sektsiya 1. Metodologiya proyektirovaniya ASU" [Report Topics of Republic Conference 'Problems of Development and Prospects for Development of ASU in the Coal Industry,' Section 1. Methodology of ASU Design] (Donetsk, 24-26 November 1976), Donetsk, 1976.

6521
CSO: 1863/108

CURRENT PROBLEMS OF DEVELOPING THIRD STAGE OF AUTOMATED SYSTEM FOR STATE STATISTICS

Moscow VESTNIK STATISTIKI in Russian No 10, Oct 83 pp 43-48

[Article by N. Ivanov and A. Maslyanenko, Central Statistical Administration of USSR]

[Text] A great deal of attention was devoted in the speech of General Secretary of the CPSU Central Committee Comrade Yu. V. Andropov at the June (1983) Plenary session of the CPSU Central Committee to problems of the efficiency of social production due to a fundamental increase of labor productivity, improvement of the use of productive capacities, raw material, energy and working time and a sharp reduction of manual labor, mainly as a result of integrated mechanization and improvement in management of the national economy. All this is fully related to the computer network and the automated system for state statistics (ASGS) of the TsSU SSSR [Central Statistical Administration of the USSR] which is being developed.

The ASGS was developed according to scientific methodological and planning documents that determine its content as an intersector accounting-statistical data gathering and processing system, required for accounting, planning and management of the national economy.

The ASGS is a complex, multilevel system which was developed in stages and is being turned over in separate portions for industrial operation. The first stage of it, the main content of which is extensive use of computers for working out the largest and most labor-consuming statistical problems, was created in 1971-1975. During work on the second stage of the ASGS in 1976-1980, basically a branch network of computer centers was formed at all territorial levels of the system of the Central Statistical Administration of the USSR, and improvement and conversion of bookkeeping to YeS computers continued. Work was also carried out to standardize the information support, to develop functional subsystems for individual sectors of statistics and to introduce the first stage of automated data banks (ABD) and of the statistical data teleprocessing system (STOSI) into operation. The four shared-resource computer centers (VTsKP), created in the system of the Central Statistical Administration of the USSR, made it possible to accumulate experience in statistical data processing under conditions of a developed hardware base of the computer centers and also to assimilate data teleprocessing.

Further development of functional subsystems, introduction of progressive technology to statistical data processing using ABD and STOSI and also development of automated statistical data processing devices, oriented toward the statistician user by making available devices for online access to the information resources of the ASGS are provided by the program for solution of the scientific and technical problems of the State plan for the economic and social development of the USSR for 1981-1985. It is also planned to make extensive use and to develop systems software. Special attention was devoted to making the work on interaction of ASGS and ASPR [automated control system for planning calculations] and sector ASU more active.

The characteristic feature of the third stage of the ASGS and its main tasks are introduction of the work which was experimental in nature or was in the development stage during the 10th Five-Year Plan at the computer centers of the Central Statistical Administration of the USSR. Thus, a number of important investigations on accelerated introduction of ABD, STOSI, applications program packages (PPP) and new hardware, i.e., all the supporting subsystems of the ASGS, had to be carried out for universal development of the functional subsystems.

The "Technical assignment for development of ASGS for 1981-1985," worked out in 1981 and in which methods of further improvement of all the functional and support subsystems are planned, in which the detailed composition of the tasks of the third stage of the ASGS is given and in which the basic directions of solving them are indicated, is of important significance among the general systems scientific methodological materials.

Working programs for the current five-year plan for each sector of statistics and special technical assignments for development and creation of functional subsystems for 18 sectors of statistics, each of which contains the basic positions and tasks of the subsystem, a list of the forms of statistical bookkeeping and accounting, the data of which is planned for processing on a computer, and also tasks related to the use of ABD and to development of an information reference service system of the central organ of the Central Statistical Administration of the USSR, were approved in 1982. Development and introduction electronic statistical data processing complexes (KEOI) at the computer centers of the system of the Central Statistical Administration of the USSR are being continued. Conversion of the software of the systems KEOI to YeS computers is being completed.

Conversion of statistical data processing to YeS computers made it possible to achieve a reduction of the processing deadlines during the elapsed period of the 11th Five-Year Plan and to publish materials on a number of EOI complexes: by 2.5 months for the systems KEOI "Basic operating indicators of an industrial enterprise (object)," form No 1-tp (annual), by 2 months for the systems KEOI "Processing of budget materials of the population in groups" (annual), by 15 days for the unionwide KEOI "Total volume of industrial production of higher category of quality" skh No 1-p-VK (monthly), by 17 days for the unionwide KEOI "Fulfillment of tasks on conservation of fuel, thermal energy and elecric energy" form No 11-sn (annual and quarterly) and so on.

Along with reducing the data processing deadlines, the programs of development were expanded and the number of output tables was increased considerably with a significant reduction of expenditures of manual labor for many EOI complexes.

However, the deadlines for development of software were not always maintained. Introduction of systems EOI complexes according to form No 1-motor transport, form No 22 (annual) and form No 9 (annual) was very difficult. The GVTs [main computer center] of the Central Statistical Administration of the USSR did not systematically monitor step by step the quality of programs being developed; there were deficiencies in organization of monitoring the consumption of funds and postulation of tasks was not always high quality.

To bring order to the work on the software of KEOI, centralized development of it was entrusted to the Main Computer Center of the Central Statistical Administration of the USSR. The cost of developing the software and of operating it in the computer center should be indicated in the technical assignment for new EOI complexes. The Main Computer Center of the Central Statistical Administration of the USSR concludes an agreement with the republic computer centers (RVTs)--the executors of the work--both for development and for introduction of the software of each complex. This work is also paid for through the republic computer center for more effective monitoring and to increase the responsibility of the computer centers of the statistical administrations of the autonomous SSRs, krays and oblasts participating in development and introduction of the EOI complexes. The Main Computer Center of the Central Statistical Administration of the USSR annually concludes an agreement with Glavmekhschet [Main Administration of Computer Operations] of the Central Statistical Administration of the USSR for the total necessary for development and introduction of all EOI complexes.

Introduction of a unified operating environment at all computer centers of the system of the Central Statistical Administration of the USSR, which is accomplished by specialists of the Main Computer Center of the Central Statistical Administration of the USSR, is of important significance for reducing nonproduction expenditures and for increasing the quality of applications software. This work will be completed this year. Moreover, it is planned to utilize applications program packages more extensively to reduce the programming time and to make possible corrections. All this should not only reduce the deadlines for development of EOI complexes but should also increase the quality of software, provide accelerated introduction of new KEOI and also provide a saving in all phases of their development and operation.

A no less important task is interaction of ASGS with the automated system for planning calculations (ASPR). The Coordination plan for design and introduction of ASPR during the 11th Five-Year Plan, in which tasks for joint functioning of ASPR and ASGS and other OASU (sector automated control system) were formulated with regard to accumulated experience, was confirmed in 1980. This work is now being conducted in 28 EOI complexes of the ASGS. The work practice on interaction of ASGS and ASPR, ASU Gossnab and other OASU confirmed that it is now more efficient to use magnetic tape during data exchange between different systems for the current complexes. Data transmission channels

can be used to solve online information reference service tasks. Experience shows that the main problems of joint functioning of automated systems are related to the phases of postulation of the tasks and of providing information compatibility of accounting and planning indicators. The developments of software rather than of functional subsystems have been involved to the greatest extent in problems of interaction until recently. However, more active participation of economic specialists and methodologists is required for solution of most problems of interaction since the difficulties related to hardware and development of software have already been essentially overcome.

The development of information support in the third stage of the ASGS is directed toward improvement of all its constituent parts (systems of indicators, unionwide classifiers and documentation systems) and daily use of them in statistical data processing, provision of unity of classification and coding of statistical data and standardization of accounting and statistical documentation on meaningful and formal features.

The Central Statistical Administration of the USSR has adopted the necessary measures on introduction, management and further improvement of unionwide classifiers of technical and economic information (OKTEI). Specific measures have been worked out and confirmed on replacement of departmental (local) classifiers with unionwide classifiers and on the corresponding modification of the software of EOI complexes. A total of 27 unionwide classifiers of technical and economic information, of which 14 are used in statistical accounting, has now been worked out. The Scientific Research Institute of the Central Statistical Administration of the USSR manages the unionwide classifier of technical and economic and social indicators (OKTESP) and, as the pilot organization in development of the unionwide classifier of enterprises and organizations (OKPO), has also completed introduction of the automated management system for SOATO and OKPO on YeS computers and has confirmed and dispatched to the Central Statistical Administrations of the union republics the regulation on management of unionwide classifiers of technical and economic information used in the system of the Central Statistical Administration of the USSR. The Main Computer Center of the Central Statistical Administration of the USSR is conducting significant work on timely actualization of OKPO, of the unionwide classifier of industrial and agricultural production (OKP) and on organization of management of other unionwide classifiers in the computer network of the Central Statistical Administration of the USSR.

At the same time, specific difficulties are being encountered in introduction and use of OKTEI. The Unionwide classifier of worker occupations, salaried employee positions and wage scales, which should be supplemented with a number of important indicators used in state statistics for the characteristics of labor resources, needs modification. There is no refined list of classification objects in the unionwide classifier of construction products and there is no series of grouping features used in planning and accounting in the OKP. Some ministries and departments have not provided the enterprises with the corresponding unionwide classifiers, which creates difficulties upon introduction of them in statistical accounting forms. The Central Statistical Administration of the USSR continues to work on further improvement of unionwide classifiers of technical and economic information used in state statistics.

The most important problem of ASGS--creation and development of the ISKhOD automated database--is being solved in such basic directions as expansion of the database and of the composition of problems to be solved, development and introduction of automated databases into operation at a number of republic computer centers of the Central Statistical Administration of the union republics and of the computer centers of oblast statistical administrations and also investigation of the capabilities of creating a distributed automated data bank.

Development of the software of the ISKhOD automated data bank for the ASGS during 1981-1985 is directed toward expansion of the its functional capabilities, development of formulation programs and actualization of database funds, publication of output tables described by the user and edited by computer, recovery of the database on current developments from the KEOI and program integration of the automated database with the STOSI. Conversion of the software of the ASGS automated data bank to the OS YeS [YeS operating system] was completed in 1982. The ISKhOD automated data bank for ASGS will be created at all shared-resource computer centers and at a number of computer centers using computers with main memory of not less than 1 Mbyte by the end of the five-year plan.

The indicators have already been selected at the republic computer centers of the Central Statistical Administration of the Tadzhik SSR and at the Central Statistical Administration of the Latvian SSR and formulation of the database of the automated data bank is being completed. Work has begun on the newly created VTsKP [shared-resource computer center] of the Central Statistical Administration of the Lithuanian SSR, the Central Statistical Administration of the Kirghiz SSR and the Central Statistical Administration of the Kazakh SSR on creation of a data bank. It should be noted that approximately 2,000 queries were realized during 2 years of operation of the first stage of the automated data bank. At the same time, the accumulated experience shows that the composition of the information database and the functional capabilities of the data bank require further development. Solution of this problem largely depends on the active use of automated data banks by economists and statisticians. Effective use of the data bank and constant improvement of it are possible only with constant communication of them with such a modern tool as the automated data bank.

Experimental operation of STOSI based on the firmware of the Main Computer Center of the Central Statistical Administration of the USSR, the republic computer center of the Central Statistical Administration of the Ukrainian SSR and the republic shared-resource computer center of the Central Statistical Administration of the Belorussian SSR and of the Central Statistical Administration of the Estonian SSR was completed last year. The "Technical assignment for development of a statistical data teleprocessing system for 1982-1985" and also the "Complex program of work to develop a statistical data teleprocessing system in 1982-1985" were developed and confirmed with regard to recommendations of the Committee of the Central Statistical Administration of the USSR on acceptance of the first stage of STOSI for industrial operation.

The experience of operating the first stage of STOSI showed that clear organization of work in introduction of it yields goods results. Thus, data was transmitted at a speed up to 2,400 bit/s and data files were received without errors at the Main Computer Center of the Central Statistical Administration of the USSR and at the republic VTsKP of the Central Statistical Administration of the Estonian SSR, where the hardware is constantly maintained in a working condition. The problem of data gathering and processing of some forms of urgent statistical accounting will be solved and conversion will also be made if necessary to the category of urgent accounting and the deadlines for publication of a number of monthly and quarterly reports collected by mail will be reduced with further development of STOSI--with the use of unswitched communication channels between all republic computer centers and the Main Computer Center of the Central Statistical Administration of the USSR and also connection of a number of oblast computer centers to the system. The problem of reducing the deadlines for processing urgent statistical accounting cannot be solved without introduction of STOSI at the computer centers of the oblast statistical administrations and primarily at the computer center of the system of the Central Statistical Administration of the RSFSR. According to preliminary calculations, approximately 20 computer centers of the Central Statistical Administration of the RSFSR should be joined to the republic computer center of the Central Statistical Administration of the RSFSR by telephone communication channels, while the remaining computer centers should utilize the existing subscriber telegraph network.

The hardware base of the ASGS should be developed under modern conditions with a rational combination and use of various types of hardware and development of mixed flow processes. The volumes of data to be processed are now such at many oblast computer centers, equipped with a single YeS computer, that there is no possibility of making machine time available during annual developments at these centers for solution of the tasks of even permanent clients. At the same time, a considerable number of M5000 (M5100) PVK are operating in the system of the Central Statistical Administration of the USSR and SM-1600 minicomputers are being delivered. It is quite obvious that the most labor-consuming phases of a flow process--data input, checking and output (which comprise more that 60 percent of the total volume of work in statistical data processing)--should be carried out on minicomputers. Accordingly, a technology must now be developed at which all types of computers would be used efficiently and expenditures for statistical data processing would be reduced simultaneously. We feel that the developers of the systems EOI complexes should be oriented toward this so that a combined (mixed) technology becomes standard during the next five-year plan and that fulfillment of the ever increasing volume of work be provided within the limits of allocated funds. As indicated by the experience of a number of computer centers of the system of the Central Statistical Administration of the RSFSR, joint use of YeS computers and M5000 PVK in separate phases of the flow process permits a reduction of cost expenditures by 20 percent or more for some jobs. Extensive work also remains with regard to gradual re-equipping of the hardware base of the ASGS to improve the skills of specialists, who will be involved in operation of mini- and microcomputers.

It is known that special attention is now being devoted to problems of mechanized and automated statistical and other economic data processing at the rayon level. A number of standard designs and universal procedures are being developed for statistical data processing on the M5000 (M5100) PVK, Robotron-1720 EFBM [not further identified], SM and Elektronika computers and so on. The technical assignment has been confirmed for development of a rayon level of ASGS and the VGPTI [not further identified] of the Central Statistical Administration of the USSR should complete the phase of contract and detail design in 1985. The main administrations of computer work of the central statistical administrations of the union republics should disseminate more widely the experience of leaders, should recruit skilled specialists of RIVTs [regional computing and data processing center] (GIVTs [state computer and data processing center]) more actively for holding seminars and consultations in the regions and should provide efficient use of the funds additionally allocated for these purposes.

According to the Summary plan for creation and development of ASGS for 1981-1985, work is being carried out to improve the management mechanism of the activity of the computer network (VS) of the Central Statistical Administration of the USSR. A unified information reference system that provides more efficient management of the functional processes and development of the hardware base of the ASGS should be created. The basic directions of work to develop this system are as follows: improvement of the management methods of the computer network of the Central Statistical Administration of the USSR, integrated automation of data gathering, transmission and processing required for management of this network, improvement of the quality of information support and improvement of the structure of the entire management system of the computer network.

Phased introduction of this system will make it possible to automate such basic management functions of the computer network of the Central Statistical Administration of the USSR as working out forecasts of its scientific and technical and socioeconomic development and also of the related system of long-term, five-year and annual plans for production and economic activity, management of development, use and servicing of the information and computer resources of the network, management of the scientific and technical potential of the network (material and technical support, outfitting, personnel training and so on), scheduling of scientific research work and design developments performed by organizations of the system of the Central Statistical Administration of the USSR and accounting for and checking the results of introducing them.

Practical work is now being conducted on the basis of the confirmed technical assignment to develop an information reference system which should increase the quality of the information support of the management apparatus of the computer network due to the completeness, reliability and timeliness of formulation of integrated data that reflects the status of all computer centers as objects of observation, the results of their production activity and their dynamics of development. The first results should be obtained at the end of the current year, which will make it possible to automate the processing and analyze report data on fulfillment of the production plan by the computer network at the rayon, oblast and republic level (forms Nos 1 and 2).

The economic effectiveness of the functioning of the ASGS, as is known, consists of three main parts. The first part is efficiency, which is achieved due to more complete and online support of party, Soviet and economic statistical data management organizations. The second is the saving achieved by enterprises and organizations of the national economy that utilize the hardware base of the ASGS to solve information and computer tasks. The third is efficiency at computer centers and stations of the system of the Central Statistical Administration of the USSR, which is achieved by increasing labor productivity, by reducing labor and material expenditures for processing a unit of data, by reducing the periods of return of capital investments and so on. There are specific difficulties that especially concern quantitative analysis of the first part in working out the methodological fundamentals of calculating the functional efficiency of ASGS, which we feel are very serious. Indices and a method that permit calculation of the national economic effectiveness of functioning of the ASGS in all its aspects should be developed for more complete analysis of the efficiency of the third stage of the ASGS.

6521
CSO: 1863/114

UDC 681.324

LOGIC INTERFACE PROTOCOL FOR LOCAL INTEGRATION OF USER AND COMMUNICATION COMPUTERS

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 (manuscript received 14 Dec 82) pp 35-40

[Article by engineer Vladimir Afanas'yevich Artamonov, Institute of Mathematics, Belorussian SSR Academy of Sciences, Minsk]

[Text] According to proposals of the international standards organization (ISO) [1, 2], the logic structure of a computer network can be represented by a seven-level model that includes the following logic levels: physical, channel, network, transport, session, presentation and applications (Figure 1). According to this model, the logic level is part of the information computer medium that fulfills one of the main tasks of the computer network (physical integration, control of the information channel, network control and so on). The objects of one level, localized in different systems, interact only through objects of a lower level and are service objects for data transmission to higher-level objects. The set of rules of interaction of objects with each other is called the protocol. The unit of data exchange through the interlevel interface is the interface data element. Each subsequent level (except the physical level) adds control information, called the title, to the data interface element, thus forming a data protocol element.

The physical and channel levels of a computer network, the interaction procedures of which depend to a significant degree on realization of the transmitting medium of the physical channel, and also a network level, which is the user of the service offered to the user by the channel level, are considered in the given paper. The following data protocol elements are established for the levels under consideration: package for the network level, the frame for the channel level and the data protocol element is unregulated for the physical level. Accordingly, the control procedures for these lower three levels can be separated into three autonomous (quasi-independent) groups of procedures: physical integration, frame logic integration and packet logic integration.

It should be noted that the International Telegraph and Telephone Consultative Committee (MKKTT) has standardized the three lower levels of the seven-level ISO model and recommendation X.25 have been regulated [3]. Bit transmission has been recommended by recommendation X.25 both for the "communication

machine-communication machine" (KM-KM) link and for the "user machine-communication machine" (AM-KM) or the DSE-DSE and DTE-DSE links, respectively, in terms of the MKKTT. This provides universality of the protocol and independence of the topology of arrangement of the assemblies of the communication network (KS) from the point of arrangement of the user machine. However, in some cases [4], the communication machine can be located in the immediate vicinity of the user machine, which predetermines local integration of the user machine with the communication machine. In this case the physical and frame integration procedures can be simplified significantly by using hardware that uses parallel (byte) exchange, while the data transmission speed can be increased considerably by using the direct memory access mode.

The hardware part and the physical structure of the information channel. It is assumed that models of YeS computers are used as the user machine and that models of SM-3 and SM-4 of the family of SM computers are used as the communication machine. In this case the problem of user machine-communication machine integration is solved by using the serially produced A71118 computer integration device (USVM), which is connected to a model of the YeS computers on the one hand and to the SM computers on the other hand at the rank of peripheral device. Connection to a YeS computer is possible both to a multiplex and to a selector channel. Data can be transmitted from SM computers both in the program interrupt mode and in the direct memory access mode. The maximum speed of data exchange in the program interrupt mode is 40,000 byte/s, while that in the direct memory access mode is 800,000 byte/s.

During execution of the initial access procedure, the device answers the commands of the YeS and SM computers exactly the same as any control device, differing only by the fact that it uses these commands not to work with the input-output device, but to establish communications between the channels of the integrated machines and to synchronize their operation. It should be noted that integrated machines can be separated by a distance not exceeding 65 meters according to the conditions of hardware realization.

Thus, the physical channel with local integration of the user machine with the communication network can be determined as a combination of USVM hardware and interface cables, by means of which data is transmitted between the user machine and communication machine.

The information channel for local integration of the user machine and communication network can be determined as a logic system consisting of two interacting logic modules, which exchange data (frame) protocol elements through the transmitting medium of the physical channel (by means of USVM integration). The use of local integration of the user machine with the communication network simplifies the data channel control procedures, but the basic requirements on the data formats (determined by recommenation X.25) should be observed to achieve compatibility with the superior network level.

The physical structure of the computer network with local and remote integration of the user machine and communication network is presented in Figure 2.

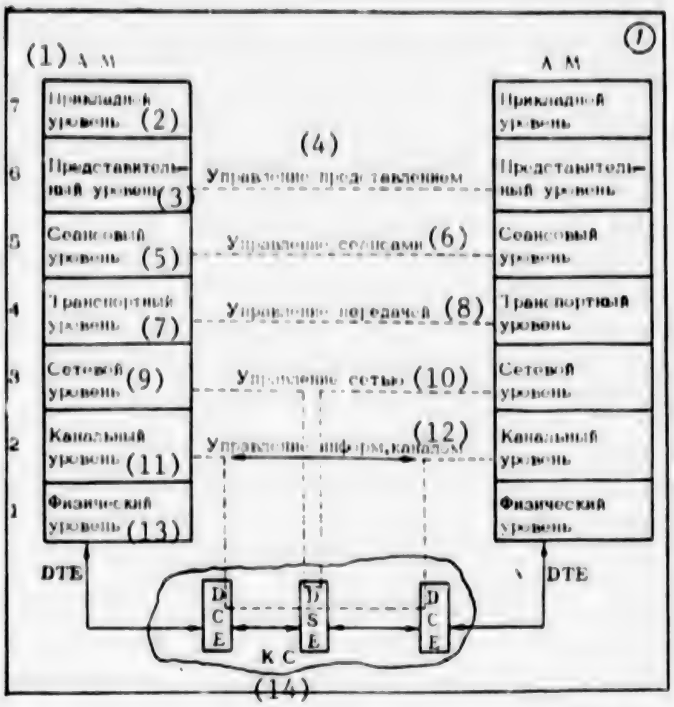


Figure 1. Logic Structure of Computer Network: solid line physical integration; dashed line--logic integration

Key:

1. User machine
2. Applications level
3. Presentation level
4. Display control
5. Sessions level
6. Session control
7. Transport level
8. Transmission control
9. Network level
10. Network control
11. Channel level
12. Data channel control
13. Physical level
14. Communication network

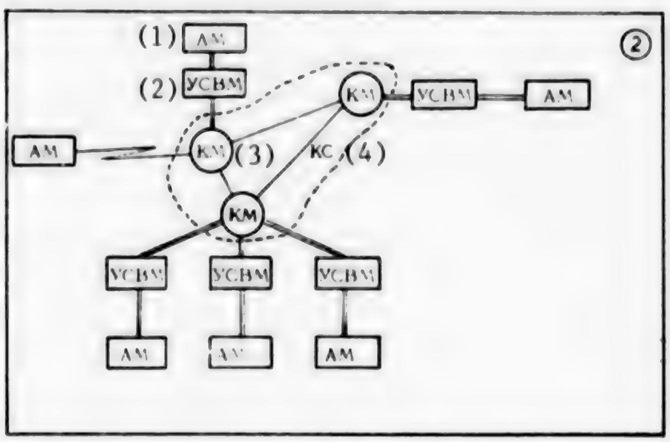


Figure 2. Physical Structure of Computer Network: --local integration; --remote integration

Key:

1. User machine
2. Computer integration device
3. Communication machine
4. Communication network

Protocol. The format and method of frame transmission through the transmitting medium of the data channel establishes the frame logic integration protocol of the user machine and communication machine. We will consider the data format and protocol as a corresponding set of agreements in three aspects:

the syntax (or format) of instructions and titles subject to transmission during data exchange;

the semantics (or significance) of these instructions and titles and what should be done upon reception of each of them;

the time sequence according to which the instructions and titles can be transmitted.

The control procedures and also the terminology of the HDLC protocol [5], recommended by ISO, was selected in the given realization of the protocol as a basis with regard to the characteristic features of hardware realization of the physical channel. The use of byte transmission, the high reliability of the physical channel and the presence of checking hardware lead to the following simplifications of frame format and frame logic integration procedures:

there are no opening and closing flags used in HDLC for synchronization;

there is no need for the bit-stuffing procedure;

the checking sequence of the frame is not calculated due to the high reliability of the transmitting medium and the existing checking by the hardware (by parity in the USVM). A check is made only along the length of the information part of the frame to be transmitted, for which the field of the data length is entered.

In the HDLC protocol, the program for control of the data channel of the machines located at the ends of the data channel that connects them can perform primary (control) or secondary (controlled) functions. Accordingly, the status of a primary station is assigned to one of the machines and that of a secondary station is assigned to the other. The two stations interact by means of selection instructions (selection of the necessary secondary stations) or query (invitation to begin transmission).

The status of the primary station is assigned to the communication machine, which permits more efficient control of the service discipline and elimination of the "competitor" mode of secondary stations to "seize" the resources of the communication machine. This operating mode (normal mode in ISO terminology) regulates the subordination of the stations of secondary status of the station having primary status, i.e., the user machine can begin transmission of one or several frames only after authorization from the communication machine. The frames transmitted by the secondary station are called responses.

The frame logic integration protocol uses three types of frames: information (I-frames), supervisor (S-frames) and unnumbered (U-frames). Data and also statements for correctly received information frames are transmitted by a means of information frames. Supervisor frames are used to control the data link, while unnumbered frames are used to implement supplementary control functions. The instructions and responses used are presented in Table 1.

Table 1

(1) Типы кадров	(2) Команды	(3) Ответы
(4) Информационный (I-кадр)	(5) I (информационный кадр)	I
Супервизорный (S-кадр) (6)	(7) RR (готов к приему)	RR
	RNR (не готов к приему) (8)	RNR
Ненумерованный (U-кадр) (9)	(10) SNRM (установить нормальный режим работы)	(11) UA (ненумерованное подтверждение)
	(12) DISC (разъединить)	UA
(13)	UREJ (ненумерованный отказ от кадра)	UREJ

Key:

1. Types of frames
2. Instructions
3. Responses
4. Information (I-frame)
5. Information frame
6. Supervisor (S-frame)
7. Ready for reception
8. Not ready for reception
9. Unnumbered (U-frame)
10. Establish normal operating mode
11. Unnumbered statement
12. Disconnect
13. Unnumbered rejection of frame

The formats of the frames used, compared to the I-frame of the HDLC protocol, are presented in Figure 3. Only I-frames have an information field and an exception is the UREJ U-frame, which has a three-byte information field.

The length of the field of the data information frame (two-byte) determines the number of bytes in the information part of the frame. The maximum number of bytes in the frame depends on the maximum length of the information field of the packet and of its title (depending on the type of packet), transferred from the network level to the channel level. MKKTT recommends the following dimensions of the information field of data packets: 16, 32, 64, 128, 256, 512 and 1,024 or in exceptional cases 255 byte. The frame control field clearly identifies the type of frame and contains control information about a change of direction of transmission, confirmation of reception of information frames and also the number of the sequence of frames to be transmitted.

The coding of the control field for the types of frames used is presented in Table 2. The frame logic integration procedures can be regarded as a sequence of actions of the primary and secondary station to establish, maintain and disconnect communications for data transmission over the data channel. The initiator of communications is always the station having primary status,

Table 2

Тип кадра (1)	Название команд (2)	Биты поля управления (3)							
		1	2	3	4	5	6	7	8
I-кадр (4)	I	0	N(S)			P/F	N(R)		
S-кадр	RR	1	0	0	0	1	N(R)		
	RNR	1	0	1	0	1	N(R)		
U-кадр	SNRM	1	1	0	0	1	0	0	1
	DISC	1	1	0	0	1	0	1	0
	UA	1	1	0	0	1	1	1	0
	UREJ	1	1	1	0	1	0	0	1

Key:
1. Type of frame
2. Name of instructions
3. Bits of control field
4. Frame

for which it transmits the SNRM frame and switches on a clock. If the secondary station correctly received the SNRM frame, then it should transmit an unnumbered statement UA to the primary station during the time out TI. The primary station switches off the time out after receiving the UA frame and changes the information channel to an active status.

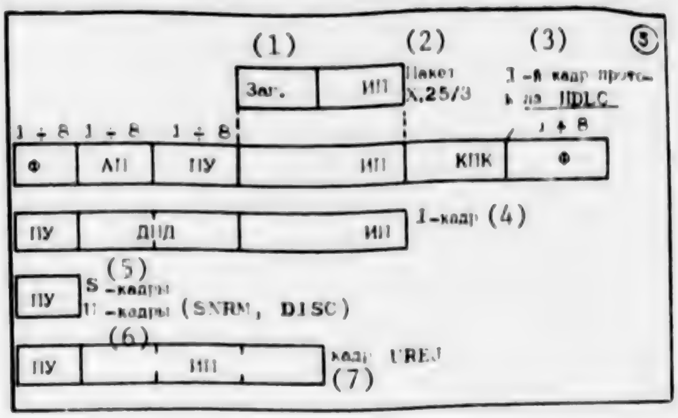


Figure 3. Formats of Frames: F--flag; AP--address field PU--control field; IP--information field: KPK--check field of frame; DPD--length of data field

Key:
1. Title
2. Packet
3. First frame of HDLC protocol
4. I-frame
5. S-frames
6. U-frames
7. UREJ frame

Prior to transmission of frames, the station checks the presence of information frames ready for transmission. The station can transmit information frames only if the RNR frame was not received prior to this. The following operations are performed in the absence of information frames ready for transmission or upon receipt of the RNR frame:

the secondary station transmits the RR or RNR frame as a function of the status of the receiving buffers;

the primary station transmits the RR or RNR frame as a function of the status of the receiving buffers if the normal disconnect condition has not been given. Otherwise, the primary station checks whether there has been an exchange of frames and if each station transmitted no more than two RR or RNR frames, it converts to the normal disconnect procedure.

If there are information frames ready for transmission and if the RNR frame is not received prior to this, the station transmits the information frame with the P/F bit equal to 0. The station checks the status of the receiving buffers prior to transmission of the last information frame and sets the P/F bit equal to 1 if the receiving buffers are free and transmits this frame. The secondary station then switches on the time out TI and changes to reception and processing of the received frame.

If the information frame is received correctly, the station (primary or secondary) checks the value of the P/F bit in the received frame and if the P/F bit is equal to 1, it changes to the transmission procedure. Regardless of the length of the received information frame and its ordinal number N(S), the station checks the ordinal number of the I-frame N(R) awaiting reception to obtain confirmation about reception of the information frames.

If supervisor or unnumbered frames are received, the station checks the absence of an information field in the frame (with the exception of the field of the UREJ frame). If the received supervisor or unnumbered frames contain an information field (or the UREJ frame contains an information field not equal to three bytes), the station shapes and transmits the UREJ frame. If an unnumbered frame is received, the station performs the following operations:

the ordinal number of reception of N(R) is checked upon reception of an erroneous UREJ frame and the station switches to the disconnect procedure (the primary station) or answers with an UREJ frame (the secondary station), depending on the status;

the secondary station transmits a UA frame and stops fulfillment of procedures upon reception of a DISC frame (it is transmitted only by the primary station);

fulfillment of the procedure is stopped upon reception of the UA frame if the primary station transmitted the DISC frame prior to this;

the secondary station transmits a UA frame upon reception of the SNRM frame;

transmission of the response UREJ frame, upon reception of which the primary station switches to the disconnect procedure, is called upon reception of the UREJ frame by the secondary station.

Reception of a frame with the F bit equal to zero by the primary station causes the clock to switch on.

The primary station transmits the DISC frame for disconnection of communications upon fulfillment of the disconnect conditions and switches on the time out TI. The only received frame which is correct after transmission of the DISC frame is the UA frame. All the remaining frames are erroneous and lead to transmission of a time out.

Realization of the protocol. The software (PO) that realizes the frame integration protocol includes two components:

the program part in the operating medium of the user machine (OS YeS);

the program part in the operating medium of the communication machine (OS RV [real-time operating system]).

Specific difficulties, related to fulfillment of input-output operations for the integration device (USVM), which is nonstandard for the OS YeS, occur when programming the protocol in the environment of the user machine. Therefore, the REAL-TIME SUPERVISOR applications program package (PPP SRV) is used to support functioning of the USVM within the YeS operating system. In this case the PPP SRV provides:

use of nonstandard input-output devices (USVM) in the user machine;

short response time in processing the data coming through the USVM;

on-line work with the USVM when fulfilling channel programs written by the user;

designation of user programs for on-line interrupt processing from the USVM;

the capability of multiprogram data processing using the disciplines of program dispatching for real-time systems;

making programs available to users in the real-time mode higher in priority of use of the central processor and input-output channels compared to the YeS operating system;

high degree of interruption of the YeS operating system with respect to the input-output devices and external interrupts serviced in the real-time mode;

masking of programs that realize input-output functions (interrupt processor and channel program) in the real-time mode due to interruptions of the operating system;

communication of user programs performed in real-time with the operator;

the capability of recording events that occur in the computer system.

The software modules that organize communication of the user machine with the communication machine through the USVM operate in two modes: with connection of their own interrupt processor (mode 1) and with the interrupt processor of the YeS operating system (mode 2).

The status of the input-output system is determined by mode 1 at the beginning of operation. Upon arrival of the interrupt signal, control is transferred from the USVM to the user program that performs the functions of interrupt processor. The peripheral device description unit that contains the channel and device status bytes and also the refined status bytes is accessible to its own interrupt processor.

The interrupt for transmission of the status byte with the indicator PERIPHERAL DEVICE FINISHED (VUK) signals the user machine program about the readiness of the device and accordingly the programs of the communication machine for joint operation. In this case the program of the user machine is converted to the event pending status, included in the arrival of the ATTENTION (VNM) character that signals the requirement to begin the communication sessions with the communication machine.

After the interrupt with the VNM character has been received and processed, if the readiness signal has already been received, the control program switches off its own interrupt processor (conversion to mode 2) and adjusts for exchange of frames with the program of the communication machine.

The frames are then exchanged according to the functional part of the protocol.

The frame exchange cycle is completed at the initiative of the communication machine by transmission of the DISC frame with P bit equal to 1, to which the user machine responds with the statement UA with bit UF equal to 1. The END character that causes an interrupt with transmission of a status byte with indicators KAN.K and VUK to the channel of the user machine, is then transmitted by the communication machine. Reception of the status byte that informs the central processor of the user machine about the completion of the communication cycle with the communication machine causes a message to be shaped about completion of work of the given cycle, which is transmitted to the upper level (for example, the network level). In this case fulfillment of the program complex by the SRV aids is completed.

We note that the use of the PPP SRV is more economical for realization of the frame integration protocol from the viewpoint of the required resources. The capacity of the main memory occupied by the SRV for specific generation does not exceed 20-24 Kbyte, while the capacity of the program that realizes the functional part of the protocol does not exceed 10 Kbyte (for comparison: the use of the graphic method for similar realization of the aids would require no less than 50 Kbyte of main memory). At the same time, the response of the system in the real-time mode is considerably higher and the operating delays of the YeS operating system, related to interrupts of its own processor, are not high since no more than 50 instructions are used for realization of it.

The software of the communication machine that realizes the frame integration protocol consists of two programs: the USVM driver and the monitor. Both programs function in the medium of the real-time operating system of SM computers.

The driver is a constituent part of the control program of the real-time operating system and is connected to it at the system generation phase. The driver analyzes the function code, which is transmitted to it by the monitor by the corresponding directive of the control program, starts the input-output operation in the device and reports the cause of completion of the operation to the monitor by the device by transmission of an input-output status block.

The driver consists of two modules: control units and input subprogram to the driver.

The control blocks of the driver include the description blocks of the device, control of the device and description of the controller, which carry all information about the integration device and determine the main strategy of input-output control.

The second driver module consists of two tables and control subroutine for the device. The driver assigns the address of the control block of the device to the first table of the USVM which causes the interrupt. All possible points of entry to the driver (upon interruption from the device, starting of input-output, time out, stopping of input-output and also upon failure of the power supply) are defined in the second table. The input-output subroutine selects the query for input-output from the list of requirements, analyzes the code of the required function and starts the operation in the device. As can be seen from that enumerated above, the driver performs the functions of control of the integration device in the input-output system of the communication machine operating system, but does not perform the functional part of the protocol, which makes the driver invariant to different versions and modifications of the protocol, while it makes the protocol independent of tne operating environment.

The functional part of the protocol is performed by a monitor consisting of a main module and functional and service modules.

The main module controls the course of the phases of the communication session of the communication machine with the user machine (each phase is executed by a separate functional module) and also analyzes the declaration for a communication session, the status of completion of phases and the necessary decision-making. The main module communicates with the other modules by means of the interface table of the monitor.

The functional modules realize individual phases of the communication session:

initiation of the KM-AM channel through the USVM and establishment of the operating mode;

initiation of the AM program (transmission of the VNM character and of the corresponding supervisor frames) to reception or transmission of the sequence of frames;

transmission of information frames to the user machine;

reception of information frames from the user machine;

completion of a communication session by transmission of the END character or disconnection of the channel.

The service modules analyze completion of one or another phase of the communications session and transmit the corresponding message to the operator or to a higher level in case of abnormal completion.

The functional modules of the monitor do not exercise direct control of the USVM. They transmit functional codes, which the device should fulfill, and the necessary supplementary information to the driver by using the control program directive to place the input-output query in the queue. Having received the parameters of this directive, the driver starts the input-output operation in the device. Upon completion of the operation (normal or emergency), the driver returns the information about completion to the monitor in the form of a specific block.

With respect to the medium of a real-time operating system, the monitor that realizes the frame integration level is determined as a task started by the corresponding higher level monitor.

Conclusions. The developed version of the frame logic integration protocol that provides a logic interface for local integration of a user machine with a communication network can be used in development of experimental computer networks with packet switching and also for design of multimachine complexes that meet the requirements of open-systems architecture.

BIBILIOGRAPHY

1. Provisional Reference Model of Open Systems Architecture (Revision 1), ISO/TC 97/SC 16, 1978.

2. Yakubaytis, E. A., "Arkhitektura vychislitel'nykh setey" [Computer Network Architecture], Moscow, Izdatel'stvo "Statistika", 1980.

3. Recommendation X.25. Interface Between Data Terminal Equipment (DTE) and Datapublic Data Networks, Geneva, CCITT, 1976.

4. Shigin, G. A., "Packet-Switching Networks and Systems," ZARUBEZHNAYA RADIOELEKTRONIKA, No 3, 1981.

5. High-Level Data Link Control Procedures. Proposed draft of international standard on elements of procedures (independent numbering), ISO/TC 97/SC 6 (Tokyo-17), editorially revised 1975.

6521
CSO: 1863/104

UDC 681.324

ODA-20M MONOCHANNEL TERMINAL NETWORK

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 (manuscript received 14 Aug 83) pp 40-44

[Article by Candidate of Technical Sciences Semen Naumovich Zharovskiy, Insitute of Cybernetics, Ukrainian SSR Academy of Sciences, Kiev]

[Text] Terminal networks with ring or monochannel architecture have recently become widespread among the variety of architectures of computer networks. This was caused by the growth of the "intelligence" of modern terminals, based on mini- or microcomputers with sufficiently high computing capabilities, which determines the development of trends toward decentralized data processing and conversion of large VTsKP [collective-use computer center] to data (knowledge) banks.

The reason for the increased interest in terminal networks also includes the need to provide efficient interaction between the lower links in the hierarchical management structures in production and in other spheres, without which the development of "paperless" technology and the significant increase of labor productivity are unthinkable.

Terminals are joined into a local network on the principle of functional communications and territorial proximity, repeating to a specific degree the existing structure of the production contacts of human collectives at an enterprise, in an association, sector and so on.

The terminal network should provide communications of each user with any other user included in the network and also with the computer center or a higher-level network.

The highest technical and economic indicators of the "each with each" type network are provided by ring and monochannel architectures. High data transmission speed is typical for a ring network since the stations connected in series in the ring are joined by wideband cable (coaxial or fiber optics) and the signals are relayed at each station, being transmitted from station to station, and reach the addressee.

The stations are connected in parallel to the channel in a monochannel network. In this case it is more difficult to provide high data transmission

speed, since there are branches in the channel that make it difficult to match lines, the channel parameters depend on the data transmission route and relay is usually not employed. Therefore, wire networks of monochannel architecture (as lower speed) found application in terminal systems in which no high requirements are usually placed on data transmission speed and at the same time there are great restrictions on the cost of equipment and communication channels.

The ODA-20M terminal network was developed with respect to problems of automation of data exchange at the lower level of the ASU [automated control system[, ASUTP [automated production process management system] and also to expand the functional capabilities of servicing the remote users of VTsKP. Moreover, factors of increasing the computing capabilities of terminals based on microcomputers by interaction with other terminals of the network (collective use of each user's resources and execution of tasks in parallel) were taken into account.

The following requirements were posed in this case:

to provide semiduplex data transmission over lines with different characteristics (including dedicated telephone communication lines) up to 20-30 km long;

to provide the maximum use of the capacity of the channel and of its sections between the source and recipient of data;

to develop a control system that realizes an HDLC-type protocol, interaction of processes that permits remote input of tasks, parallel processing and real-time operation;

to provide homogeneity and unity of hardware and software that realize data gathering, processing and also data transmission based on microcomputers;

to provide the capability of branching of the network (from two or more monochannels) and interaction with networks of other levels and configurations.

The user station of the ODA-20M network is a multifunctional intelligent terminal based on microcomputers, which includes a program-controlled modem module. Input-output devices and other computers of various types can be connected to each microcomputer (Figure 1, a) through the corresponding interface modules (IM). The operator interacts with the system through the console (display).

User stations can operate to one, two or more monochannels (Figure 1, b), which permits the users of different monochannels to link up with each other through an intermediate station.

Thus, different network devices: terminal stations, interface machines, data transmission multiplexers, network adapters and other equipment--can be configured from user stations, the nucleus of which are microcomputers, by using

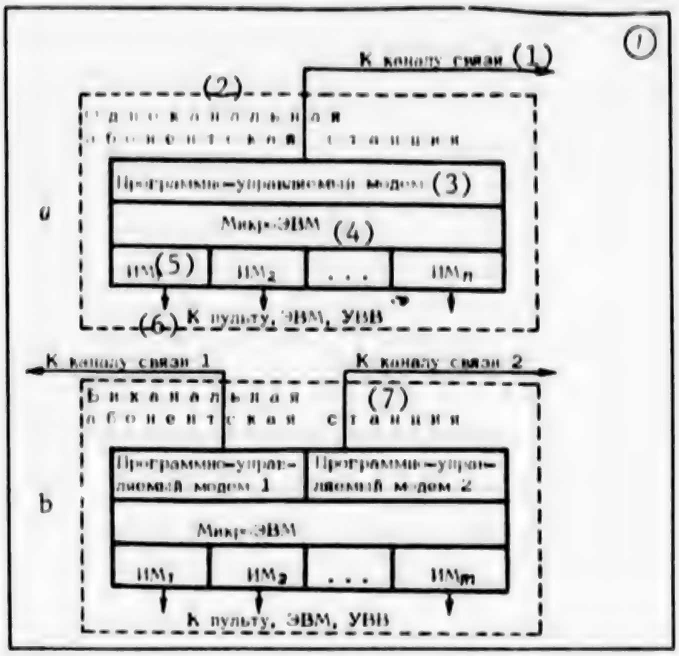


Figure 1. Structure of User Station: a--single channel; b--bichannel

Key:

1. To communication channel
2. Single-channel user station
3. Program-controlled modem
4. Microcomputer
5. Interface module
6. To console, computer or input-output device

a set of interface modules and program-controlled modems. A high degree of equipment homogeneity is achieved in this case. By analogy with the modular set of microprocessor equipment [1], one must develop a modular set of network aids that meet modern requirements in overall dimensions, cost and standardization not only of designs but of most modules that comprise the hardware of the network. This ideology was the basis in development of the user stations of the ODA-20M network.

The functions of the user station are as follows:

transport of data and management directives in the network, initiated by intrastation processes (a directive from a console, from the program to be executed and also from a computer);

retransport of data in multichannel stations from one network to another;

servicing of peripheral devices;

intrastation data processing;

remote input of tasks;

operation of the station in the multiprogram mode;

operation of the station in real time.

Selection of the exchange protocol in the network is determined by the functional characteristics of the network, recommendations worked out by international and union-wide agreements, prospects for development of the network to be designed and of networks as a whole and by the capabilities of realization in the framework of specific technical and economic indicators.

This problem is especially acute for local networks (they also include the network under consideration), for which there are still no generally accepted standards and if such standards do appear [2], then they will hardly take into account fully all the diversity of applications of local networks. An attempt was made in [3] to systematize the exchange protocols of existing local networks. It is shown that the standard protocol of open HDLC networks can be the basic protocol for developing the protocols of local networks. It is assumed that we should be talking about development of a class of exchange protocols based on HDLC protocol. Introduction of the concept of the class of exchange protocols, based on the basic standard protocol, assumes the following:

simplification of the requirements on the exchange protocol of a specific local network, proceeding only from its functional conditions. As a result there is minimization of redundancy in the service data to be transmitted and a reduction of the processing time of transport tasks;

achievement of compatibility of different protocols belonging to the same class by adaptation of user stations. The technical basis of this adaptation is the new generation of network equipment--programmable aids based on microcomputers, distinguished by high adaptability;

the capability of full realization of the basic protocol of each user station, which guarantees integration of networks with the protocols of the same class.

The exchange protocol of the ODA-20M network is a modification of the protocol of class HDLC, in which the functional characteristics of a monochannel network with decentralized control and competition mode are taken into account (Figure 2, a). The level of the physical channel is provided by the program-controlled modem. Synchronous data transmission is carried out by the relative signal phase manipulation method. One period of the carrier frequency is expended on transmission of 1 bit. A timing series for synchronization of the receiving and transmitting stations is transmitted to the line prior to transmission of the data packet (Figure 2, b).

The transmission speed of a monochannel network is usually determined on the basis of the capacity of the line that connects users more remote from each other. This speed is considerably lower than the possible speed for most of the shorter data transmission routes in the network.

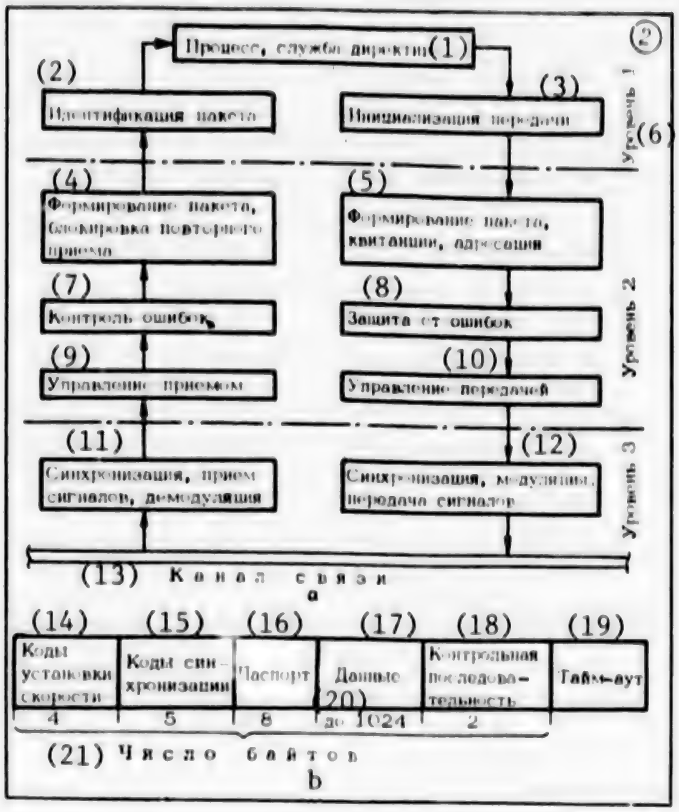


Figure 2. Structure of Exchange Protocol (a) and Format of Data Packet (b)

Key:

1. Process and service of directives
2. Identification of packet
3. Initialization of transmission
4. Shaping of packet and interlocking of repeat reception
5. Shaping of packet, acknowledgment of receipt and addressing
6. Level
7. Error check
8. Error protection
9. Reception control
10. Transmission control
11. Synchronization, reception of signals and demodulation
12. Synchronization, modulation and transmission of signals
13. Communication channel
14. Speed setting codes
15. Synchronization codes
16. Certificate
17. Data
18. Check sequence
19. Time out
20. Up to
21. Number of bytes

An increase of the efficiency of using the capacity of the monochannel is achieved by adaptive systems, in which the transmission speed is a function of the distance between users conducting the data exchange. One can show that adaptation of transmission speed to the length of the route yields a significant advantage in the average rate of exchange for the case when the stations are located uniformly along a monochannel of length L with distance of $l \ll L$ between adjacent stations:

$$V_{cp}/V_0 = \frac{K\,(L_{cp})^{-2}}{K\,(L)^{-2}} \approx \sqrt{2},$$

where V_{sr} is the average speed upon adaptation, V_0 is the speed determined by the maximum length of the route, $L_{sr} = (1/2)(L + 1)$ is the length of the average route for equally probable communications of users and K is a coefficient dependent on the nature of the conducting medium.

Transmission frequency in the ODA-20M network depends on the distance between stations conducting the exchange. Moreover, the mechanism of variation of transmission speed is used as a means of optimizing packet transmission in time under conditions of constant channel parameters (fluctuations of noise level, random connections of user stations to the line and disconnection of them and other factors).

User stations in the reception mode are tuned to the frequency of the transmitting station during transmission of a timing series. Only those stations for which reception on this frequency is possible can be tuned, i.e., a permissible "signal-noise" ratio and a specific degree of phase distortions of the signal are provided.

The following changes are introduced to the level of management of the physical channel compared to the basic protocol:

a check of the channel status for fulfillment of the "listen before talking" procedure is introduced;

timeouts between transmissions in the channel are introduced;

flags that determine the beginning and end of a packet are eliminated. This function is performed by detection of the first byte, distinct from the synchronization byte, and the moment of onset of the time out;

bit stuffings eliminated.

The functions of packet service of the protocol consist in addressing of datagrams, identification of them, fulfillment of error protection procedures: shaping and checking of FSC sequences, their inclusion in the packet, transmission of receipts, repeat transmission of packets and interlocking of repeat reception of packets received correctly earlier with transmission of receipts for them. The packet service controls priority access to the monochannel of the transmitting station, controlling the extent of the time out.

Priority access eliminates collisions of packets in the network at the moment of highest probability of their occurrence--upon the onset of the time out. Possible collisions of packets remain after processing of time-outs if the channel was free and if readiness of two or more stations for transmission occurred simultaneously. However, the probability of this situation occurring is extremely low.

The station that transmits the receipt for a received packet enjoys the right of primary transmission in a channel with semiduplex communications. Priorities are established for the remaining transmissions on the basis of the nature of tasks to be performed and can be fixed and centrally or autonomously changed according to a given priority control algorithm.

The packet service interacts with processes through a special directive service--the general systems service of the distributed operating system of the station (ROS). The ROS controls teleprocessing of tasks and also the operation of the entire station.

The operating systems of most existing computers were developed with respect to centralized data processing. Teleprocessing devices were built into the general structure of the system, forming a complex and very inefficient hierarchy of procedures.

The possibility of designing an operating system as a distributed processing (teleprocessing) system arose during development of multiprocessor networks. Orientation of the system to teleprocessing assumes the multiprogram mode and common principles of task generation for remote and local users.

The method of assigning system directives, the combination of which determines the capabilities of the input-output organization, program initialization, data transmission to users of the network and other service applications, has this common basis.

The structure of the ROS is presented in Figure 3. Data addressed to a specific station is received from the communication channel with absolute priority (according to interrupt). The packet is received by protocol service of level 2 and the verified packet is then transmitted to level 3, where it is identified by the following criteria:

the data of the task to be performed at the receiving station;

transmission of confirmation;

a directive or set of directives that initiate new tasks;

checking of the channel and status of the user station.

If it is established that the received packet contains a directive, then the latter is analyzed and the system is converted to formation of the task: the required resources (OZU [main memory] or VU [computer]) are allocated, an identifier is assigned to the task and it is recorded in the identification

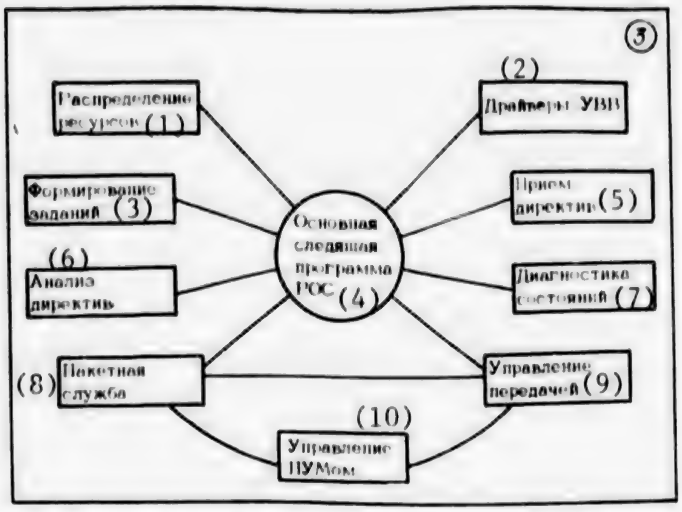


Figure 3. Structure of Distributed Operating System

Key:

1. Resource distribution
2. Input-output drivers
3. Task formation
4. Main tracking program of distributed operating system
5. Reception of directives
6. Analysis of directives
7. Diagnosis of status
8. Packet service
9. Control of transmission
10. Control of program-controlled modem

domain of the ROS for tasks in operation. Up to six tasks can be located simultaneously in each station in the ROS of the ODA-20M. The steps of performing the tasks are noted by status bytes and the sequence of performing them is noted by the priority level. A system of mixed priorities with relative priorities for tasks has been realized, i.e., any task to which control has been transferred by the processor is performed until completed or until conversion to standby status (input-output operations and clock synchronization). Control is then transferred to the higher priority tasks awaiting servicing. Packets from the channel and also a number of real-time tasks are received with absolute priority. Similar to reception of directives from a remote station of the network, they can arrive from local sources (console or computer) and can also be generated by the program to be fulfilled. Thus, each task can generate a tree of new tasks, to be completed at local or remote stations of the network.

The real-time mode can be fulfilled by two methods:

by restriction of the waiting time for task preservicing. This mode is illustrated by Figure 4. The current time from a clock (upon interrupt) or by means of systems time packets transmitted over the network from one station

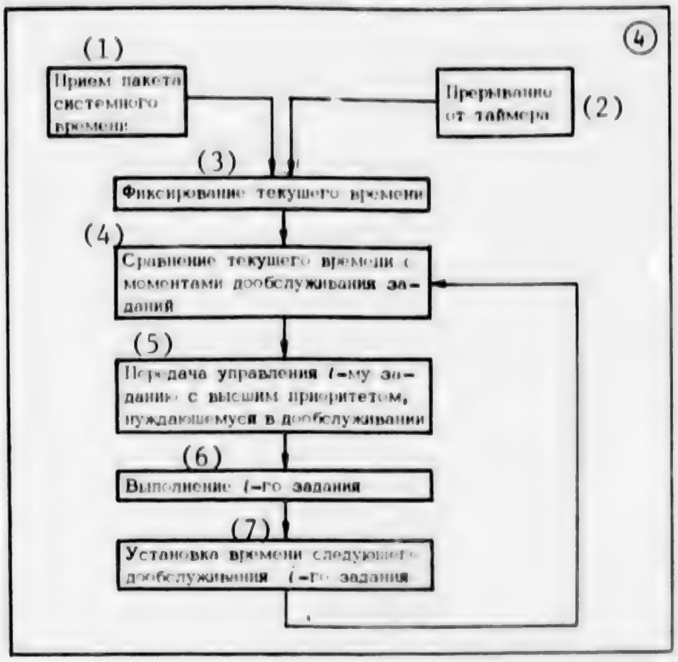


Figure 4. Block Diagram of Algorithm for Real-Time Fulfillment of Tasks

Key:

1. Reception of systems time packet
2. Interrupt by clock
3. Recording of current time
4. Comparison of current time to moments of task preservicing
5. Transfer of control to i-th task with higher priority that requires preservicing
6. Completion of i-th task
7. Setting of time of next preservicing of i-th task

with specific frequency is recorded in the memory domain of the ROS accessible to user programs. Fields identified by the names of the tasks, where the user programs carry indicators of the moments of times of the next preservicing, are allocated in this memory domain for real-time tasks. The control program of the ROS, receiving control each time, reviews this list by comparing it to the current time and transfers control to the tasks in which the preservicing delay is greater than zero. If this condition is fulfilled simultaneously for two or more tasks, control is transferred to the tasks with the higher priority. The given method of organizing the real-time mode, although it does not provide strict synchronism of the preservicing moments (delays are provided), can guarantee a limitation of the delay by a specific value (for example, by the time of continuous engagement of the processor by one task or by the time of reception of a packet from the communication channel).

by preservicing tasks according to external interrupt signals having lower priority compared to the modem interrupt signal.

The most detailed description of the distributed operating system of the ODA-20M is presented in [4]. The mode of user program fulfillment in the ODA-20M system has a number of characteristic features. Distribution of the main memory domains for each task is required for multiprogram operation of the system. A separate memory domain with capacity of 1 Kbyte is allocated for packets to be received. The remaining memory is distributed among tasks with discreteness of 1 Kbyte. The system can refuse to make available a memory resource to an incoming task if there is less than 1 Kbyte of memory available in the reserve of the system (the reserve for formation of the transmission packet over the communication channel). Since there is no relative memory addressing in a microcomputer, the user programs oriented toward absolute addresses of the main memory can be used in limited cases (for example, with a field sequence of task input). In the general case, user programs must be supplemented by address autocorrection aids or one of the system directives that fulfill this procedure must be used.

Devices to protect the memory against unsanctioned access are also not provided in the ROS, which eliminates operation in the program debugging mode at the station connected to the network.

In conclusion, we note the level of practical realization of the ODA-20M network. As already mentioned, the technical basis of design of the user station is a microcomputer. The first stage of the network, developed at the IK AN USSR [Institute of Cybernetics, Ukrainian SSR Academy of Sciences], for automation of scientific research, is designed on the microprocessor systems of the ODA-20M (series K580), characterized by the presence of a main memory of 32 Kbyte, PPZU [programmable ROM] of 4 Kbyte, interface modules for integration with the Konsul-260.1, FS-1500 and PL-150 devices and also a program-controlled modem for data transmission over dedicated telephone lines at a speed of 1,200-38,400 bit/s.

Computers of type SOU-1 and microcomputers of type SO-01 are connected to the station based on the ODA-20M by the corresponding integration modules. Stations based on the SO-01 microcomputer and the MK-01 microcontroller, for which modems and the corresponding software have been developed, are at the stage of beginning production.

Output of these user stations by industry will permit wider development of work to create terminal microprocessor networks of different designation. The design ideology of a local network realized in the ODA-20M network can be used widely in development of networks of various designation on the basis of various types of microcomputers produced by industry.

BIBLIOGRAPHY

1. Malinovskiy, B. N., A. V. Palagin, A. I. Slobodyanyuk et al., "A Complex of Microprocessor Equipment Modules," UPRAVLYAYUSHCHIYE SISTEMY I MASHINY, No 6, 1982.

2. Sideris, J., "The World Before the Appearance of Standards for Local Networks," ELEKTRONIKA, No 15, 1982.

3. Bumgart, V. F. and Yu. S. Podvysotskiy, "Channel Protocols of a Local Network," in "Vychislitel'nyye seti kommutatsii paketov" [Packet-Switching Computer Networks], Report Topics of the Second All-Union Conference, Vol 2, Riga, 1981.

4. Abysov, P. L., S. N. Zharovskiy and N. V. Puninskiy, "Organization and Functional Principles of a Local Microprocessor Network," in "Preobrazovaniye, peredacha i obrabotka informatsii v vysokoproizvoditel'nykh mikroprotsessornykh sistemakh" [Data Conversion, Transmission and Processing in High-Performance Microprocessor Systems], Kiev, IKAN USSR, 1983.

6521
CSO: 1863/104

THIRD ALL-UNION CONFERENCE 'DIALOG-83'

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 pp 119-120

[Article by Candidate of Physicomathematical Sciences Stanislav Vladimirovich Klimenko, Institute of High-Energy Physics, Serpukhov, engineer Leonina Nikolayevna Nekrasova, Institute of Cybernetics, Ukrainian SSR Academy of Sciences, Kiev, and Candidate of Physicomathematical Sciences Ol'ga Leonidovna Perevozchikova, Institute of Cybernetics, Ukrainian SSR Academy of Sciences, Kiev]

[Text] The Third All-Union Conference "Dialog-83," held from 5 through 7 July 1983 at Protvino, Moscow Oblast, was prepared and conducted by the Council on Automation of Scientific Research, Presidium of the USSR Academy of Sciences, and by the Institute of High-Energy Physics, USSR GKAE [State Committee for Atomic Energy]. More than 250 scientists from 29 cities and 138 scientific centers and organizations of the USSR Academy of Sciences, the academies of sciences of the union republics, GKAE, other ministries and departments of the country participated in the conference.

A total of 190 reports, many of which were discussed widely, was heard at two plenary sessions and seven section meetings.

The characteristics of a system, in which decentralization of control on the basis of distributed computer networks, high-level languages and organization of dialogue at all management levels are used, were noted in the report of V. A. Yarba (Protvino) "Automated System for Interactive Control of the Accelerator-Storage Complex of IFVE."

Determination of the informatics of both fundamental natural science, which studies data transmission and processing, was given in the report of A. P. Yershov (Novosibirsk), the task of developing a data processing industry was posed, comparative analysis of the means and resources was made for design of integrated programming systems for the period up to 2005 and the problem of creating a programming lexicon was also formulated.

U. M. Bayakovskiy (Moscow) and B. A. Utochkin (Protvino) analyzed the activity of the international scientific association Eurographics from the time of its creation and noted the problems of developing the hardware and softawre for graphics interaction.

S. S. Lavrov (Leningrad), indicating the trend toward universal informatization of society and the need to create unified methodological bases for development of interactive systems, enumerated some as yet unresolved problems of development and assimilation of interactive languages and noted the feasibility of recruiting psychologists to constructing an individual psychological portrait of the user at the terminal.

V. M. Savinkov (Moscow) devoted his report to problems of organizing a dialogue in SUBD [database management system] and IPS [information retrieval system] and emphasized the need to standardize the interactive servicing aids by analogy with the established standardization of the functions and aids of the SUBD. V. M. Volchkov (Protvino) and V. A. Rostovtsev (Dubna) considered the problems of organizing a dialogue in analytical computation systems. V. P. Klimenko, S. B. Pogrebinskiy and Yu. S. Fishman (Kiev) turned attention toward the mathematical and engineering aspects of interactive realization of numerical-analytical methods of solving scientific tasks by using the serially produced SM1410 two-processor complex. The capabilities of machine graphics in applications program packages were discussed in the report of P. V. Vel't-mander (Moscow). G. Yu. Veprinskiy (Kiev) informed the conference participants about a new second-generation graphics ARM [automated workstation].

The following topical sections worked at the conference: methods and means of interactive system programming, systems engineering devices, interactive machine graphics, methodological and theoretical problems of interaction, interaction in analytical computation systems, problem-oriented interactive systems and interaction in SUBD and ASU.

A number of section reports should be noted. O. L. Perevozchikova and Ye. L. Yushchenko (Kiev) formulated the primary problems of development of interactive systems and suggested a method of classifying them, illustrating it by analysis of the development of interactive systems in the Ukraine. B. T. Shreyber (Moscow), Ye. G. Tumanova (Leningrad), L. V. Kokareva (Moscow), L. N. Nekrasova and V. S. Yakovleva (Kiev), S. K. Kornya (Kishinev), A. M. Britmanis (Riga) and T. N. Kul'man (Protvino) reported about organization of interactive information servicing in the UNISON, SPIRIT, SEKIRA and DISPLAR systems and also in interactive data processing systems in astronomy, prognosis analysis, medicine and so on.

A great deal of attention was devoted in the section reports to systems support of interaction and to tools for design of interactive systems. A wide range of problems of realizing new production procedures in organization of dialogue was touched on in the reports of S. P. Yefimenko (Kiev), I. P. Brusentsov (Moscow), I. Ye. Shvetsov (Novosibirsk) and A. P. Yanis and A. P. Yanin (Riga). A series of reports on such well-known systems for organization of the computing process based on the YeS7066 and YeS7927 terminal network in the YeS operating system as DISP (V. I. Tsagel'skiy, Minsk), DUVZ (V. A. Dudnik, Kharkov), TERM (V. V. Koren'kov, Dubna) and also the new application of the DZhEK system, based on new YeS 7063 intelligent terminals, for servicing the users of the YeS7970 complex (B. A. Katsev, Leningrad) should be especially noted.

A number of interesting reports were presented on organization of dialogue in task-solving systems for mechanics (G.B. Yefimov, Moscow), applied problems of

group theory and other known algebra problems (A. Ya. Rodionov, Moscow; V. A. Rostovtsev, Dubna: N. A. Tsvetkova, Protvino).

A large group of reports (more than 30) was devoted to discussion of the interactive devices of the Elektronika-60 and SM computers and also of problems of development and assimilation of raster displays that considerably expand the capabilities of conversion and reproduction of color video images (K. S. Yarosh, Leningrad, A. A. Buchnev, Moscow, S. V. Klimenko, Protvino and so on).

Participation of a group of psychologists and designers, headed by O. K. Tikhomirov (Moscow), who formulated some primary tasks of engineering psychology investigations of interactive systems and engineering outfitting of interactive devices, was useful.

The discussions of "Effectiveness of Developments and Use of Interactive Systems," (Chairman A. A. Karlov) and "Problems of Interactive Machine Graphics" (Chairman Yu. M. Bayakovskiy) aroused great interest.

The conference participants familiarized themselves with the existing interactive complexes of the Institute of High-Energy Physics.

The conference made decisions, the main propositions of which consist in the following:

1. To universally expand the volume of scientific research and industrial developments in such key directions as:

the methodological and theoretical aspects of interaction;

interactive machine graphics;

problem-oriented interactive systems, including interaction in SUBD and ASU and in analytical computations;

methods and means of interactive system programming;

systems engineering devices.

2. To strengthen international cooperation with the academies of sciences of CEMA countries and other leading foreign scientific centers in the field of development of interactive systems, specifically, with the Eurographics Association.

3. To edit an annotated collection of literature on interactive systems.

4. It is planned to hold the Fourth All-Union Conference "Dialog-84" and the Second All-Union Conference "Dialog-84-mikro" on problems of development of individual interactive systems based on microcomputers (personal computers) in 1984.

6521
CSO: 1863/104

APPLICATION OF ACTIVE TEACHING METHODS

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 p 120

[Article by Candidate of Economic Sciences Yuriy Ovseyevich Kogan, Kiev]

[Text] A total of 140 specialists of different sectors of the national economy participated in the work of the fifth interdepartmental seminar school under the same name which was conducted on 24-30 April 1983 at Yurmal. A total of 58 reports was heard, several practical exercises in which the participants became familiar with more than 15 business and role games, were conducted and several specific situations were analyzed.

The first plenary session was devoted to discussion of problems of the basic directions in development of Soviet business games, classification of active methods of teaching and also about the position and role of these methods in the training process. Such important directions of improving Soviet business games as national economic actualization of their topics, the use of multiple business games, wide-scale restructuring of teaching on the basis of integrated use of active methods of teaching, including business games, enrichment of training business games with production materials and expansion of the sphere of their application and also improvement of the method and technique of conducting them were noted in the report of M. M. Birshteyn, R. F. Zhukov and T. P. Timofeyevskiy (Leningrad).

V. I. Rybal'skiy (Kiev) and Yu. S. Arutyunov (Moscow) devoted their reports to classification of active methods of training, which should contribute to bringing order to the process of development, certification and distribution of them.

A. V. Shchepkin (Moscow) reported on games developed at the Institute of Control Problems, USSR Academy of Sciences, which are based on the theory of active systems, and Yu. M. Porkhovnik (Leningrad) reported about the system of games of the Leningrad Engineering Economics Institute, specifically, about a game in which the players simulate different computers, which permits deeper study of its structure and operation. L. N. Ivanenko (Kiev) talked about the new simulation game Urbanistika which was developed at the Institute of Cybernetics imeni V. M. Glushkov, Ukrainian SSR Academy of Sciences, on the basis of the idea of conceptual design and is conducted through the system of Ukrainian television. The report of A. A. Verbitskiy (Moscow) was devoted to

the problem of activity training in games, which corresponds in pedagogical work to a higher level of complexity than simply a transfer of the sum of knowledge--information.

The section work of the seminar-school included the following directions: the method and experience of using active methods of teaching in the training process, the experience of using business games in sectors of the national economy, the hardware and software of active methods of teaching and psychological problems of heir development and use.

In the opinion of the participants of the seminar-school, the most popular and most successfully conducted games and situations in the school include: "Specific Program Control" (V. F. Komarov, Novosibirsk), "Structure of Shop ASU" (V. N. Gerasimov, Moscow), "Stimulus--Tekhpromfinplan" (L. S. Shlyakhovaya and N. B. Yablokova, Odessa), "Brigade Contract" (E. V. Dudina, Ye. V. Izmaylova and A. S. Pechnikova, Kiev), "Design of Business Games" (N. V. Borisova and A. A. Solov'yeva, Moscow), "SPUSK-POST--Preparation of a Performance in the Theater" (Yu. O. Kogan, Kiev), "Relations Within the Collective" [N. O. Kudryavtseva and A. P. Khachaturyan, Leningrad) and "Structure and People--Analysis and Formulation of Organizational Structures" (T. A. Elenurm, Tallinn).

It is planned to organize the sixth seminar-school on active methods of teaching during the first quarter of 1984 at Leningrad and to organize the seventh seminar-school in 1985 in Latvia.

6521
CSO: 1863/104

ACTIVITY OF INSTITUTE OF MATHEMATICS AND CYBERNETICS IN 1977-1981

Vilnius TRUDY AKADEMII NAUK LITOVSKOY SSR, SERIYA B: KHIMIYA, TEKHNIKA, FIZICHESKAYA GEOGRAFIYA in Russian No 3(136), 1983 pp 138-146

[Article by Ch. Sipavichyus and V. Petrauskas]

[Text] Scientific and organizational activity of the Academy of Sciences Institute of Mathematics and Cybernetics in 1977-1981 was discussed in an expanded plenary session of the Academy of Sciences Presidium on 27 October 1982. The item for discussion was prepared by the Bureau of the Department of Engineering Physics and Mathematical Sciences, Academy of Sciences, and the special commission, headed by Academician Y. Kubilyus, formed by Academy of Sciences Presidium resolution No 359 of 12 October 1981.

A. Nyamura, deputy chairman of the commission and corresponding member of the Academy of Sciences, generalized the activity of the Institute of Mathematics and Cybernetics for the period being discussed, outlined the major scientific achievements by the Institute and reported the conclusions and proposals by the commission on further improvement in institute activity.

The Institute of Mathematics and Cybernetics was established by resolution No 360 of the Academy of Sciences Presidium on 29 December 1976, "On Separating the Institute of Physics and Mathematics into Two Institutes: the Institute of Mathematics and Cybernetics and the Institute of Physics." The Institute of Mathematics and Cybernetics began operations on 1 January 1977.

The basic directions in scientific research efforts by the Institute of Mathematics and Cybernetics, which were approved by the USSR Academy of Sciences Presidum and the LiSSR Academy of Sciences Presidium resolution No 87 of 28 March 1977 are[1]:

---

1 See: M. Rimkyavichene, "LiSSR Academy of Sciences Activity in 1976," TR. AN LITSSR. SER. B, Vol 3(106), 1978, p 117; and M. Rimkyavichene, V. Petrauskas and Y. Samaytis, "LiSSR Academy of Sciences Activity in 1978," TR. AN LITSSR. SER. B, Vol 2(117), 1980, p 95.

1. Probability theory and its application to control problems. Asymtotic methods of probability theory (limit theorems, asymtotic properties of statistics of random processes, queuing theory, ergodic theory, probability theory of numbers); random process statistics (checking statistical hypotheses, random process estimation, sequential analysis); control of random processes and their recognition (control of processes described by stochastic equations, methods and algorithms for recognition of random processes and fields, numerical methods for solving differential equations); decision-making methods (principles of optimality, inference theory, methods of finding functions of the extremum of many variables, analysis of systems of network models).

2. Automation of scientific research (creation and development of shared computer systems for institutes under the LiSSR Academy of Sciences, software for automation of experimental research in random processes); software for automated control systems developed in the republic.

On 1 January 1982, the institute had 14 departments, 4 laboratories and 4 independent working groups:

Department of Probability Theory (established in 1965, director is Academician V. Statulyavichyus), Department of Mathematical Statistics (1970, B. Grigyalenis, corresponding member, Academy of Sciences), Department of Recognition Processes (1965, L.-A. Tel'ksnis, corresponding member, Academy of Sciences), Department of Reliability Theory (1964, K. Zhukauskas, candidate of physical and mathematical sciences), Department of Information and Patents (1976, Y. Masyulis, candidate of engineering sciences), Department of Computational Methods (1967, M. Sapagovas, candidate of physical and mathematical sciences), Department of Operations Research (1967, E. Vilkas, corresponding member, Academy of Sciences), Department of Mathematical Logic and Theory of Algorithms (1964, V. Matulis, candidate of physical and mathematical sciences), Department of Differential Equations (1967, V. Kvyadaras, candidate of physical and mathematical sciences), Department of Control Systems (1977, A. Baskas, candidate of engineering sciences), Department of Theory of Optimal Solutions (1969, Academician Y. Motskus), Department of Software (1969, P. Rumshas, candidate of physical and mathematical sciences), Department of Process Control (1978, Ts. Paulauskas, candidate of engineering sciences), Department of Data Analysis (1981, Sh. Raudis, doctor of engineering sciences),

Electronic Computer Laboratory (1967, B. Binkauskas, candidate of engineering sciences), Laboratory of Information Preparation Devices (1967, Y. Pyatkyavichyus) (eliminated in 1982), Laboratory for Scientific Research Automation (1979, V. Chernyauskas, candidate of engineering sciences), Laboratory of Computer Technology (1978, L. Bulotas, candidate of engineering sciences).

Systematic Programming Sector (1981, G. Grigas, candidate of engineering sciences), Program Monitoring Group (1972, O.-R. Pashkyavichene), Departmental Library of Algorithms and Programs (in operation since 1974, established in 1981, V. Dragunene, director), Section for Experimental Production of Computer Hardware and Software (1977, L. Bulotas, candidate of engineering sciences).

Table. Basic Indicators of Activity for the Institute of Mathematics and Cybernetics of the Academy of Sciences for 1977-1981.

Indicator	Year				
	1977	1978	1979	1980	1981
1	2	3	4	5	6
Comprehensive programs engaged in (total):	3	4	4	5	5
all-union programs	1	1	1	2	2
tasks for all-union programs	1	1	1	2	3
republic programs	1	1	1	1	2
tasks for republic programs	1	1	1	1	2
programs directed by institute	1	1	1	1	1
Topics engaged in (total):	37	35	42	39	40
basic	15	13	15	14	12
scientific and technical (total):	4	7	11	8	28
budget	18	19	22	22	23
contract	18	15	16	17	15
Topics completed (total):	18	17	18	26	13
basic	2	4	7	4	3
scientific and technical (total):	4	–	1	7	10
budget	4	4	7	11	3
contract	14	13	10	15	10
Full economic effect of introduction (thousands of rubles)	186	279	372	558	2500
Agreements on creative cooperation engaged in	16	19	41	48	53
Publications (number of titles)	25	26	23	27	21
Publication volume (printer's sheets)	250	192	144	265	200
Patents applied for	29	35	36	53	26
Positive decisions received	42	30	33	48	22
Licenses prepared	–	–	–	–	–
Conferences organized (total)	1	2	3	2	2
all-union	–	1	1	1	1
Lectures given	149	229	160	250	250
Popular articles published	40	33	25	20	61
Scientific Days organized	3	2	1	2	3
Foreign specialists received	108	23	14	2	112
Number of trips abroad	19	21	22	24	27
Number of laboratories, departments (on 31 December):	15	17	18	18	19
Number of employees (on 31 December):	340	356	377	392	420
scientific (total):	160	167	175	178	180
doctors of sciences	4	5	6	6	6
candidates of sciences	65	67	73	75	82

Number of postgraduate students (total on 31 December)	28	37	41	46	47
resident	8	12	16	19	21
in special-purpose postgraduate course	15	15	19	15	2
Postgraduate students accepted (total)	8	13	15	12	3
resident	3	6	7	7	6
in special-purpose postgraduate course	3	3	4	2	4
Postgraduate students graduated (total)	8	6	10	10	8
resident	4	3	2	5	4
in special-purpose postgraduate course	3	1	6	3	3
Dissertations defended:					
doctoral	1	1	–	–	2
candidate	3	5	4	6	3
Floorspace (thousands of m^2) (on 31 December)	1826	1826	1826	2190	2248
Expenditures (total, millions of rubles):	1,28	1,42	1,92	2,18	2,03
capital investment (thousands of rubles)	–	–	–	–	456
construction and installation (" " ")	–	–	–	–	220
salaries (thousands of rubles)	596	609	661	722	776
scientific research work (thousands of rubles)	335	367	546	587	607
apparatus and tools acquired (thousands of rubles)	204	266	462	540	443
Receipts for contract work (without special resources, thousands of rubles)	990	1046	1192	1499	1357
Contract expenses (thousands of rubles)	801	966	1147	1450	1357

The institute had 420 employees at the end of 1981. Of these, 180 were scientists including 6 doctors (of these, 2 were academicians and 3 were corresponding members) and 82 candidates of sciences.

The basic indicators of scientific and scientific-organizational activity in the institute for the period 1977-1981 are shown in the table.

In the field of probability theory and its application to control problems, asymtotic analysis of sums of independent and slightly dependent random values and vectors was performed. Broader classes of limit laws in transition to spaces of infinite number of measurements were studied. The method of semi-invariants was used to obtain optimal estimates of rate of convergence and probabilities of large deviations under various conditions of slight dependence. For the cycle of efforts on problems of asymptotic methods of probabilities, including for the development of an original method of semi-invariants and results obtained in studying limit theorems of sums of slightly dependent random values, Academician V. Statulyavichyus (together with coauthors) was awarded the USSR State Prize in 1979.

A new class of random processes with penetrable bounds was constructed and studied; the general Martingale method for analysis of convergence of probability measures in metric spaces was elaborated.

A new class of automodel fields was constructed and their attraction regions studied. Conditions of existence and uniqueness of solution to Belmon integral-differential equations were found and properties of their smoothness investigated. New efficient methods for solving nonlinear differential equations which describe real processes in engineering physics were developed.

In developing economic models and solving problems in economics and management, many principles of optimality for group solutions were axiomatized; several general game solutions were refined. Finite uncooperative multiperson games were structurally reduced to three-person games.

Problems of cooperation and equilibrium of dynamic economic models, equilibrium price stability, and new principles of optimality were studied. For work in game theory, E. Vilkas, corresponding member, was awarded the LiSSR State Prize in 1977. In research on recognition processes, the theory of recognition of random processes and complex signals was elaborated; methods of automating recognition signals were developed. For efforts in this area, L.-A. Tel'ksnis, corresponding member, was awarded the LiSSR State Prize in 1980.

Principles were developed for solving axiomatic multiextremal problems (in the sense of mean error). Developed to solve problems in management and planning were methods, algorithms and software packages to automate planning of developmental efforts, monitoring and management. A programming technique was devised on the basis of types of abstract data in the "Assembler" language and other mathematical languages. The theory of analysis of mean time between failures was developed for high reliability discrete action systems. Mathematical models of complex dynamic systems were investigated.

In the field of automating scientific research, major efforts were carried out on developing the Academy of Sciences Computer System for Shared Use. The central computer complex with the terminal network was established and expanded; the hardware and software complex providing the capability for automating scientific research data processing was developed; progressive methods for solving problems in the interactive mode using displays were assimilated.

In the 10th Five-Year Plan, the Institute of Mathematics and Cybernetics stepped up activity considerably on introducing scientific results into industry. In 1977-1981, about 60 efforts pertaining to the basic subjects of institute research were introduced. The economic effect of the efforts introduced was increased. The experimental-production section was formed in 1977 to design and produce nonstandard computer hardware, measuring apparatus and control equipment. Major assemblies including pulse generators and data recorders and regenerators were manufactured at the institute. About 50 percent of institute inventions are used in the national economy.

The detailed design was prepared for data bases and software for the Republic Automated System for Management of Capital Construction; assistance was rendered in developing system software for republic computer centers.

The institute maintains close contacts in creative cooperation with many scientific institutions and specialists in the republic, the country and abroad. In 1977-1981, the institute executed about 50 agreements on creative cooperation (first place in the Academy of Sciences). Very large-scale international conferences on probability theory and mathematical statistics were organized.

The republic scientific Society of Lithuanian Mathematicians (chairman is Academician Y. Kubilyus) has been quite active at the institute (since 1962).

Since 1961, the institute (together with republic VUZ's and the Society of Lithuanian Mathematicians) has been publishing the LITOVSKIY MATEMATICHESKIY SBORNIK (which has had the status of a scientific journal since 1968).

Seven permanent seminars have been operating at the institute for many years: "Differential Equaltions and Their Application," "Mathematical Methods in the Social Sciences," "Automating Planning and Management Processes," "Application of Probability Theory and Mathematical Statistics," "Statistical Problems of Management," "Theory of Optimal Solutions," and "Computer Programming." Methodological material for these seminars is systematically published in the appropriate series of publications.

The institute is a patron of secondary schools (Vilnius, Utena, Shilute) and organizes republic olympiads for young mathematicians as well as correspondence mathematical schools and schools of programming for students.

Eight people took part in the discussion.

A. Dambrauskas (deceased), chief of the Academy of Sciences Postgraduate Department, noted that the institute must more precisely plan training of highly skilled scientific employees, doctors and candidates of sciences, and more strictly monitor execution of the plan.

Academician Y. Motskus, director of the Department of Theory of Optimal Solutions, Institute of Mathematics and Cybernetics, suggested using the principle of optimal distribution of facilities between subdivisions performing basic research and those engaged primarily with applied topics. Special attention should be paid to subdivisions carrying out governmental tasks and comprehensive programs. It would be nice if each institute subdivision would investigate both theoretical and applied problems.

Academician Yu. Pozhela, Academy of Sciences vice-president, said the institute should further expand and strengthen the experimental-production section, introduce more achievements in applied mathematics and cybernetics in the republic national economy, and expand the efforts related to the Academy of Sciences Shared-Use Computer System. The institute can contribute a lot to introducing microprocessors and robots for hardware into production. The institute must have the best organizational strategy in constructing a new building for the institute and in expanding and strengthening the computer center.

Academician V. Statulyavichyus, director of the Institute of Mathematics and Cybernetics, noted that progress in probability theory, mathematical methods and their application to solving management problems will remain the basic direction of scientific research in the institute.

The institute will aim at not limiting itself to its own problems and will also be studying aspects of mathematics that are relevant to other fields of science such as theoretical physics and semiconductor physics, engineering, medicine, biology and agriculture.

All scientific and applied research at the institute can be conventionally divided into three groups:

Group I includes basic research in problems of mathematics, in the first place probability theory and mathematical statistics, and differential equations and problems of cybernetics. Also included here are studies in some problems of applied mathematics in which engineers and cyberneticists successfully work together with mathematicians. The practical results of this research are usually brought to concrete recommendations, models, algorithms and software packages suitable for direct application.

Group II includes application of mathematical models in economics. Here, mathematical problems of equilibrium of the socialist economy are solved, mathematical models are developed for economic management, algorithm development for processes of planning and management is investigated, major software packages are developed for automated sector network planning and management, and research is performed on the make up and management of data bases needed to establish the republic automated management system.

Group III includes research on mathematical logic, theory of algorithms and preparation of software.

In the institute, mathematics and cybernetics work well together and this yields great benefits. The small departments in the institute have their own unofficial branches in other Academy of Sciences institutes and other departments; we cooperate closely with the directors of them in common seminars.

Many applied efforts are performed in the institute and many of them are large in scale. Self-supporting work makes up more than 50 percent of institute efforts which is now too much for the institute .

Quite a few problems are posed by the construction of the institute building and computer center. Construction matters would be better resolved if aspects of construction design and organization were more closely coordinated between republic organizations.

Academician L. Kayryukshtis, academician-secretary of the Department of Chemical Process and Biological Sciences, pointed out that the institute must pay more attention to efforts on developing the Republic Automated Management System and give more help to biological institutes and subdivisions to introduce mathematical methods and automate their research.

E. Vilkas, deputy director of the Institute of Mathematics and Cybernetics and corresponding member of the Academy of Sciences, noted that despite the fact that invention indicators in other Academy of Sciences institutes declined somewhat in 1980-1981, they remained fine in this institute. It should also be noted that invention is not the main field of institute activity. The Institute of Mathematics and Cybernetics did not receive quite a lot of planned equipment and materials because of objective reasons.

V. Paulauskas, member of the commission, professor at Vilnius State University imeni Vintsas Kapsukas and doctor of physical and mathematical sciences, noted that biologists must themselves formulate problems for mathematicians to more extensively and efficiently make use of aid from mathematicians. As is the case now with geneticists and others, all biologists should also have mathematicians working together with them in their groups.

Speaking at the end of the discussion, Academician Yu. Matulis, Academy of Sciences president, said the commission organized the review effort well. It was performed according to the detailed program compiled in advance. The question of proportions between senior and junior scientific associates in the departments is not new. Chemists undertook to solve it 20 years ago. This ratio depends on the nature of problems and efforts being solved, namely: first, on what type of efforts, theoretical or applied, the subdivision pursues and second, on what subjects we want to strengthen in the subdivision. If a subdivision pursues basic research, junior scientific associates and service personnel are needed to implement the results obtained in practice. When applied research has to be intensified, the number of junior associates and engineers has to be increased. The ratio used by biologists or physicists-experimenters is really not suitable for mathematicians.

World practice in recent years also indicates that in experimental institutes, it is actually inadvisable to allocate employees to those engaging in theoretical efforts and those engaging in applied research. The universal course now is to give up abstract problems and hypotheses in basic research; special-purpose research is practiced more and more extensively. Selected are those hypotheses and models, the results of solving of which can be applied as fast as possible in a particular sector of industry and in practice.

The distribution mentioned above would yield only "aristocrats" and "servants." The former would not understand practice and would not be able to even advance hypotheses needed for practice, while the latter would be removed from the theory and perspectives of science. But basic research underway has to be properly completed and the results transferred to practice and introduced into it. We have to be guided by this. But we should not overload those preparing dissertations with applied efforts.

The question of incentives raised in the session is very important. Best results will be achieved when the value of incentives and their ratio in basic and applied efforts are properly considered by directors and the collective and depend on the importance of problems being resolved. They cannot be fixed. When basic research has to be intensified, we must beforehand provide

for larger prizes for the theoreticians. When we want to speed up the solution to applied problems, greater incentives have to be offerred to the associates investigating engineering subjects and performing self-supporting efforts, governmental tasks, and special-purpose programs. A change in the ratio between incentives very effectively influences results of scientific effort and the interest in them.

These issues have to be discussed in the Scientific Council in the institute.

But the institute is still not training enough doctors of sciences and in this area lags behind other Academy of Sciences institutes and the Vilnius State University imeni Vintsas Kapsukas. The rates of training them have to be speeded up.

In the comprehensive program for automating scientific research, the institute must perform the role of strategists in using computers. Concrete programs for automating research and measures must be developed by the most interested institutes; they themselves must pose and formulate concrete problems for mathematicians and cyberneticists.

The Institute of Mathematics and Cybernetics is doing well in invention.

The Academy of Sciences Presidium adopted the resolution (No 363) "On Scientific and Scientific-Organizational Activity of the Institute of Mathematics and Cybernetics in 1977-1981," in which it gave a favorable rating to institute activity, pointed out certain shortcomings in its activity and specified future institute scientific effort and organizational activity.

The Academy of Sciences Presidium indicated that progress in the institute in mathematical logic is still poor, especially in areas relevant to solving problems in automating software development and raising efficiency of checking programs. The institute can still more closely cooperate with social science institutes, especially the Institute of Economics. Major engineering departments have a minimal number of employees, and the proportion between senior and junior scientific associates is not the same in all departments and subdivisions. The institute has to raise the effectiveness of special-purpose postgraduate work. The central computer complex still does not have enough hardware and software. The Institute of Mathematics and Cybernetics is not giving enough help to other Academy of Sciences institutes in solving problems of using computers. There were cases of violations of requirements for hardware safety and financial discipline in the institute.

The Academy of Sciences Presidium believes it advisable in pursuing efforts on the basic scientific directions of the institute in the future to concentrate institute manpower and physical resources for the fastest consideration of major basic problems and pursuit of relevant applied efforts.

For the problem of probability theory and mathematical statistics, plans call for developing research on the theory of random processes and fields, investigating probability distributions in spaces of an infinite number of

measurements and in algebraic structures, expanding research of asymptotic properties of multilinear forms of random processes, investigating limit theorems of sums of dependent values in Banach spaces, studying the probability aspects of stochastic differential equations, elaborating the probability theory of numbers, and expanding efforts on applying probability methods in statistical physics, biophysics and cybernetics.

For the problem of differential equations, plans call for expanding research in linear partial differential equations, studying nonlinear differential equations with a free surface, studying stochastic differential equations, evolving methods of enhanced accuracy for approximate solutions to differential equations, developing software for automated solving of differential equations, and expanding efforts on using methods of differential equations to solve problems in engineering and mechanics and develop biological models.

For the problem of mathematical cybernetics and discrete mathematics, plans call for elaborating the theory of economic equilibrium, developing new models of functioning of economics designed to investigate its social aspects, studying problems of the theory of decision making related to mathematical economics in searches for new principles of optimality for markets and social management, developing statistical methods of global optimization, and expanding efforts in mathematical logic by elaborating the theory of logical proof and studying problems of assessing algorithm complexity.

For the problem of engineering cybernetics, plans call for elaborating the theory, methods and algorithms of recognition of random processes, developing adaptive methods of analysis of random processes, developing filters for identifying dynamic stochastic objects and controlling them, and studying problems of design of systems insensitive to noise.

Plans call for developing software for the BESM-6 and Unified Series computers, more advanced programs and packages for solving topical problems in science, industry and engineering, particularly development of industrial robots, expanding efforts on development of software for calendar planning and management, and control of mini and micro computers, and speeding up efforts on developing software to carry out special-purpose and comprehensive scientific and technical programs.

For the problem of automating scientific research, plans call for speeding up efforts, together with other institutes, on developing a general academic system for automating scientific research.

Plans call for expanding special-purpose basic research which allows solving major practical problems.

The institute is charged with:
active participation in solving republic and union comprehensive programs;
aiming for evolving effective research results relevant to the national economy to their technological application and broader introduction in industry, and aiming for analysis of their economic effectiveness;

examining the possibilities of raising effectiveness of labor in small engineering departments, and the problems of intensifying cooperation between mathematical and cybernetic departments, and closer cooperation with the Institute of Economics and other social science institutes;

speeding up efforts on developing concentrators for terminals in the Central Computer Complex (TsVK) by using the EVM-1010, further expanding the network of peripheral installations in the Central Computer Complex, and aiming to make the academic library of algorithms and programs a high quality methodological center for concentration and dissemination of algorithms and programs in the republic, setting goals for further development of the experimental-production section for computer hardware and software, and concentrating in it development and production of software and special assemblies and instruments for computer hardware;

improving publication of results of completed applied efforts and investigation of their market conditions abroad, and achieving their commercial implementation;

establishing rational proportions between senior and junior scientific associates with regard to scientific topics handled in the subdivisions in the departments and laboratories;

further improving training of highly skilled scientific employees, raising skills of scientific associates, postgraduate work, raising the effectiveness of special-purpose postgraduate work, and using incentives more effectively to encourage introduction of scientific results in industry.

8545
CSO: 1863/54

PUBLICATIONS

TABLE OF CONTENTS OF UPRAVLYAYUSHCHIYE SISTEMY I MASHINY, NO 6, NOVEMBER-DECEMBER 1983

Kiev UPRAVLYAYUSHCHIYE SISTEMY I MASHINY in Russian No 6, Nov-Dec 83 pp 1-2, 128

[Table of contents and author information]

[Text] Contents Page

General Software of Control Systems

Data Banks and Information Retrieval Systems

Applications Program Packages

6521
CSO: 1863/104

- END -

END OF FICHE

DATE FILMED

9 MAY 1984